POWER

Volume 54 New York, August 30, 1921 *Number* 9

The Interest of the Principal

YEARS ago I had an old Holland gardener, John. He took an honest pride in his work. The borders were well kept and he delighted in introducing new shrubbery and flowers and effects and looked to me for delighted appreciation.

But I was occupied with other things and passed it by with a careless, "That's fine, John—very pretty."

Finally the old man, hurt and provoked by my indifference said, "Mr. Low, if a man would have a garden he must look on him." I smiled at the Hollandized English of the remark then, but the serious significance has since come back to me many times.

If a man would have a garden he must look on him.

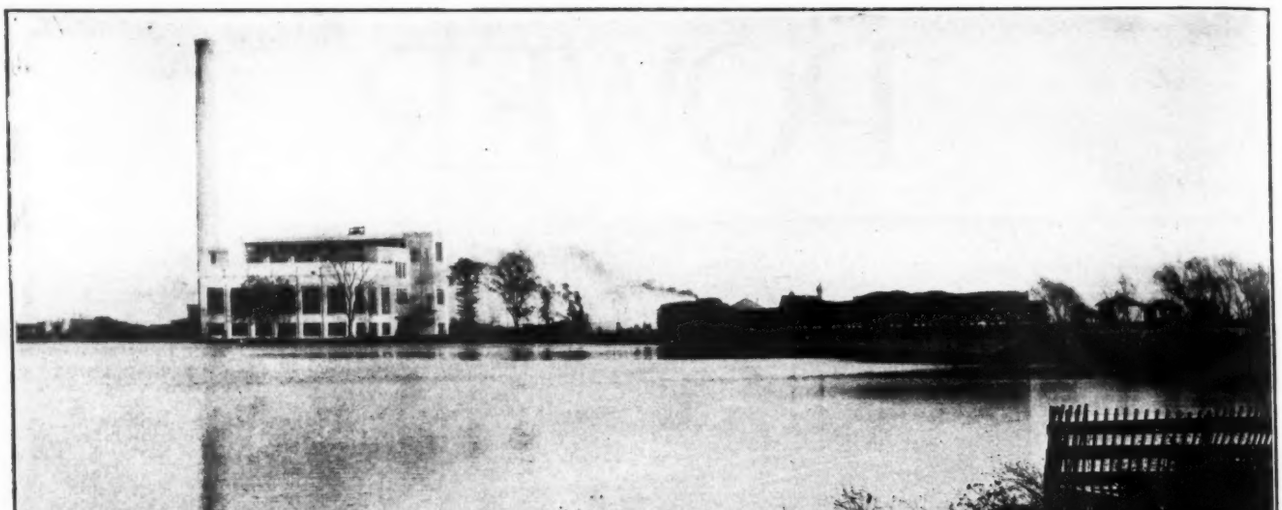
If a man has an object in life, a task to perform, a job to make good in, he must "look on him." He must have an intelligent, appreciative interest in it.

When I got a really active interest in my garden, when I smoked my after-dinner pipe among the flower beds and shrubbery and pulled a weed or two here, or pinched a superfluous bud there, or trained a misdirected vine, or headed off the attack of insect enemies or suggested new combinations and effects, the garden bloomed with a new beauty. Not only were my own casual ministrations effective, but the old man was aroused to new interest and application.

Many a chief engineer is going on as I was with my garden. It was all right, and so is his plant. It was running as well as the average neighbor's, and so is his plant. He "Looks on him" as a job, but what are the possibilities if he would "Look on him" as an opportunity, as a hobby; if he would take some pains to see what the plant is really doing, to analyze its performance and see if it cannot be made to do better, and how?

And there is the earnest, interested engineer, wrestling with his power plant, as John wrestled with my garden, for a careless and unappreciative owner or manager. Absorbed in other, perhaps larger, things, he fails to respond to the interest-inviting displays of records and accomplishments, or to give the necessary approval to carefully thought-out plans for increased efficiency. The keenest interest will soon be blunted against this sort of insusceptibility, and talent which might be applied and developed and savings which might be made, go by the board, simply because the boss will not make the effort necessary to overcome his inertia and "look on him."

F. R. Low



Standard Oil Mine Plant at Schoper

A 6,250-kw., three-unit plant serving electrically three coal mines featured by forced-draft chain grates in the boiler room, use of concrete in the settings and a waste-heat superheater at the rear of the boiler. Coal is dumped from railway cars into the overhead bunker and the same type of car receives the ash at grade.

THE DIFFICULTY of securing coal of the desired quality and in sufficient quantity during the industrial expansion resulting from the late war, led the Standard Oil Co., of Indiana, to secure coal mines of its own for supplying its various refineries and as a source of power for operating these mines to erect a modern power plant. An established mine in the town of Carlinville, Ill., having an output of about 400 tons per day was purchased. Its capacity was enlarged to a daily run of 1,200 tons and 1½ miles distant another shaft was sunk with a tunnel connection between the two. From the latter, known as the Berry mine, 2,500 tons may be turned out per day. Nine miles away at Schoper the coal rights on certain properties were purchased and a mine is being developed that eventually will be one of the largest and most modern in the state requiring the services of over 1,000 men. At present the daily output is about 800 tons. To secure greater flexibility and economy, the new mine is electrically operated throughout, including the hoists, mining machinery, air compressors, pumps and haulage. The same is true of the other two mines, with the exception that in the older mine under Carlinville, the steam hoist has been retained.

About one-half mile from the new Schoper mine is the site of the power house. It has a capacity of 6,250 kw. in three units, generating current at 6,600 volts, three-phase, 60 cycles, and is served by four boilers, each having 5,000 sq.ft. of steam making surface, an allowance of 3.2 per sq.ft. of heating surface per kilowatt of generator rating. The importance of economy in the plant as well as in the mines, was fully realized, so that in the selection and layout of the power-plant equipment, economy was the primary factor. To handle successfully the variable loads common to coal mines, where the demand may vary rapidly in the ratio of one to three, forced-draft chain grates were installed under the boilers, and in the latter superheaters were installed at the rear of the settings to recover as much waste heat as possible from the flue gases. Other features of interest are the use of concrete in the boiler settings, the water supply from an artificial lake and the simple, direct methods of handling coal and ash.

Reference to the headpiece will show that the power-plant building is of reinforced concrete after the style of architecture generally adopted by the Standard Oil Co. The company has been liberal in providing for the comforts of the employees. Shower baths, lockers, toilets and other facilities are available and homes for the operating force have been constructed in proximity to the plant, which are of modern design, with bath, toilet, electric lights and furnace.

As it was not desirable to place the condensing equipment below the level of the artificial lake, the plant has no basement, the condenser auxiliaries being installed at grade level and the main generating units and the boilers on the second floor, thus giving the height necessary to dispose of the ash directly into railway cars.

Fig. 1 is a view of the boiler room showing four units set individually, each containing 5,000 sq.ft. of steam-making surface. There is space in the boiler room for two more units of the same capacity, which will be installed as soon as needed. Reference to Fig. 2 will show that the boilers are horizontally baffled for three passes, and between the boiler proper and the rear wall is a space down which the outgoing gases are drawn to the smoke flue. This flue passes underneath the boiler-room floor to a concrete stack exterior to the building, which is 12 ft. in diameter at the top and rises 213 ft. above the foundation.

In the space at the rear of each boiler is located a waste-heat superheater, designed by A. P. McCormick, chief engineer of the Wood River plant of the company. This superheater receives the steam from the boiler at 170 lb. pressure and at 200 per cent of rating will superheat it about 100 deg., utilizing heat

that would otherwise be wasted. The superheater consists of two drums suspended vertically, between which 290 two-inch tubes pass horizontally across the boiler setting. As shown in Fig. 3, the steam enters at the bottom of one of the drums and by means of interior baffling, is made to pass back and forth four times through the tubes before it escapes at the top of the drum into the main steam header. In the tube ends are placed cast-iron reducing plugs, as indicated in Fig. 3, in line with the flow of the steam to insure equal distribution throughout the entire surface of the superheater. The form of this plug is indicated in the drawing.

From each superheater an 8-in. pipe leads to the main steam header, of 12 in. diameter, located back of the boilers. Drop pipes of the same diameter at either end connect with a delivery header underneath the boiler-room floor, thus forming a vertical ring header with four sectionalizing valves, from the lower run of which 5 and 8-in. supply pipes lead to the turbines and a 3-in. lead to the auxiliaries.

In the plan view, Fig. 2, is shown the construction of the setting walls. The side walls are made of 9 in. of firebrick, 4 in. of insulating brick and on the exterior 9 in. of concrete, with the firebrick bonding into the concrete wall as indicated. In the rear wall the insulation is omitted, there being 9 in. of firebrick and 10 in. of concrete. The concrete was used merely as a covering, as it had given good service for the same purpose at the Wood River plant of the company. It is not exposed to severe temperature and the hand may be placed on it without any discomfort. The boilers have been in operation for over a year and with the exception of a little surface cracking, there are no defects in the concrete boiler walls. The boiler setting is suitably braced and the boiler itself is suspended from steel work as indicated in the drawing. This same illustration, Fig. 2, shows that the lower, front drum header is set 12 ft. above the floor, giving the comparatively large furnace volume necessary for high rates of combustion.

As a coal mine load is variable and it was estimated in this particular case that it would have a range of 3 to 1 at intervals throughout the day, it was desired to install a stoker equipment flexible enough to meet these peaks with the units that might be in operation rather than carrying continuous extra boilers on the line to help out at maximum load. To burn Southern Illinois coal chain grates were desirable and the forced-draft was selected to obtain the flexibility desired. It was anticipated that operation on this order would increase considerably the overall economy of the plant, as the coal that would otherwise be required to carry extra boilers would be saved, and the combustion effi-

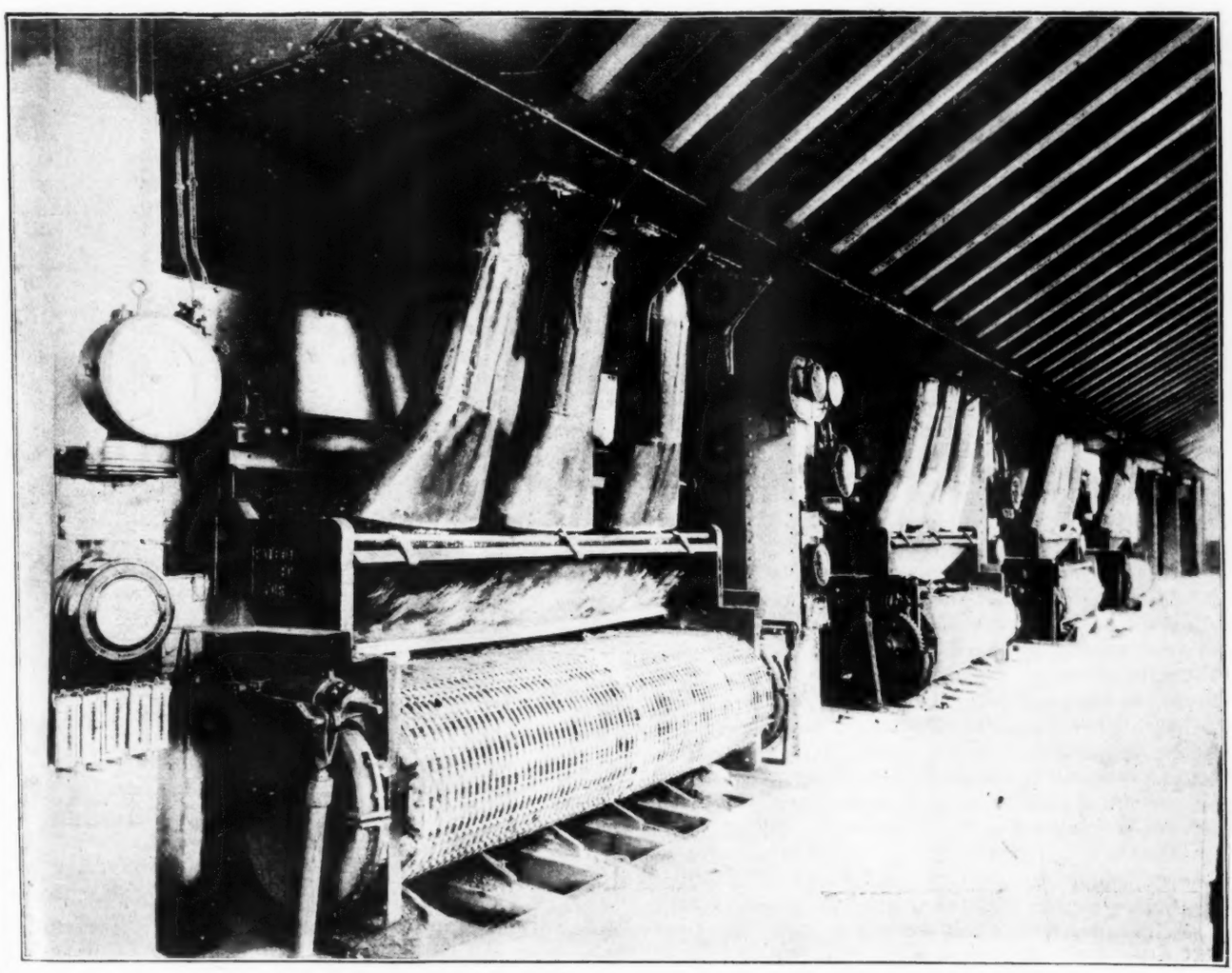


FIG. 1. PRESENT BOILER EQUIPMENT SERVED BY FORCED-DRAFT CHAIN GRATES

ciency would be higher by supplying air more nearly in the proper proportions to the various sections of the grate.

Each stoker is 10 ft. wide by 12 ft. long, giving an active grate surface of 120 sq.ft. which to the steam-making surface bears a ratio of 1 to 41.7. The stoker has five zones with an individual blower for each zone.

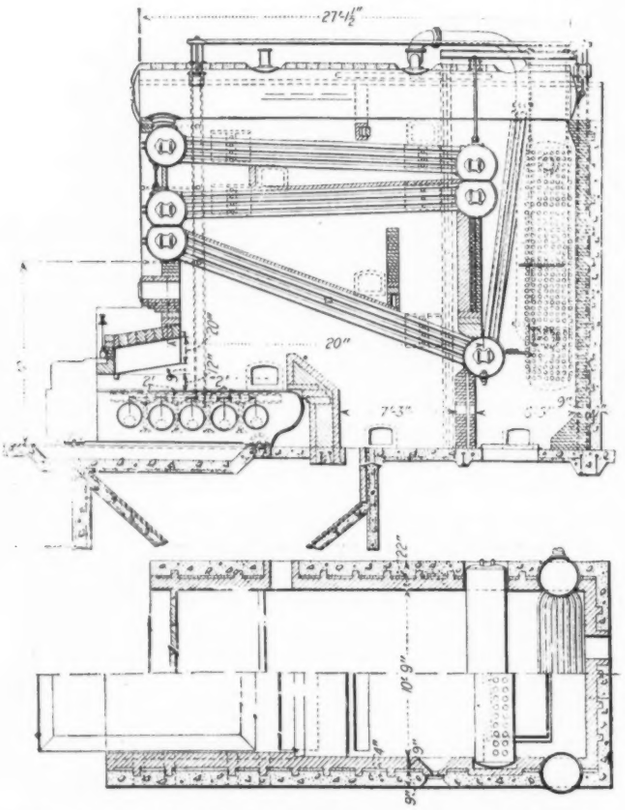


FIG. 2. PLAN AND ELEVATION OF BOILER SETTING

Air for combustion is first used for cooling the main generating units. By the generator fan it is drawn to the machine from the outside or from the turbine room as the seasons may warrant, and is discharged through ducts which to farther increase the temperature of the air, pass around the main smoke flue of the boilers before discharging into a compartment underneath each stoker. Before reaching the compartment, however, part of this warm air may be used for heating the turbine room. The floor of the latter is 5 ft. lower than that of the boiler room, so that wall registers leading into the air duct may be opened when it is desired to allow a portion of the hot air to escape into the turbine room.

From the compartment or chamber under the stoker, each of the five fans draws its supply. The amount of steam supplied to the five fans and therefore their speed is controlled by a damper regulator. This regulator, controlled by the steam pressure, sets the boiler damper at the proper opening to prevent waste of steam in case of a drop of load and controls the valve in the steam supply to the fans, as well as the throttle of the stoker engine. To the steam supply header each fan has its connection, and a valve in each of these lines provides for hand adjustment of the relative amount of steam supplied to each blower. There is a bypass around the regulating valve on the supply header, which is used principally when starting up. Siftings that may collect in each zone are blown into a compartment at the side of the setting, opening downward into a hopper from which the fuel may be discharged into railway cars and returned to the overhead bunker. The hopper is located at the side of the ash hopper which is built of reinforced concrete and likewise is arranged to discharge into railway cars through gates operated by air cylinders.

Power to drive the stokers is supplied by two vertical engines located on the first floor, which are belted to a line shaft suspended from the boiler-room floor. Provision is made also to drive the line shaft by a motor used ordinarily in the machine shop. The line shaft is belted to an individual jack shaft serving each stoker, having loose and tight pulleys and an eccentric for driving the stoker.

To give the data necessary for efficient operation, each boiler has its individual instrument board mounted on a steel column supporting the bunker and located at the boiler front between the settings. As indicated in Fig. 4 there is a pressure gage for each boiler, a steam flow meter to record the output, a differential draft gage with connections over the fire and at the outlet, a recording pyrometer to take the flue temperature and U-tube draft gages to indicate the pressure in each zone. CO_2 readings are taken with an orsat.

Operation of the plant is so nearly automatic that only nine men are required to operate the plant continuously. They are distributed as follows: Three engineers, consisting of the chief engineer and two running engineers; three firemen, one on each shift; an oiler and two men of general work.

As a typical example, it is not necessary to touch the coal by hand from the time it is loaded at the

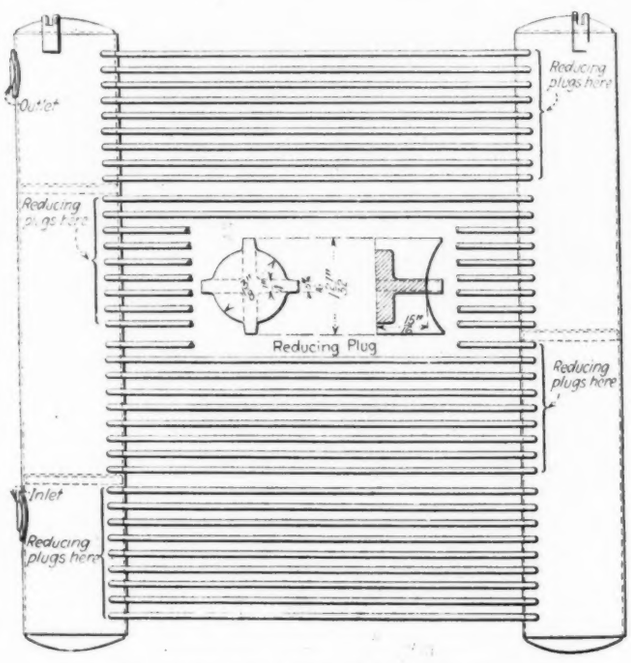


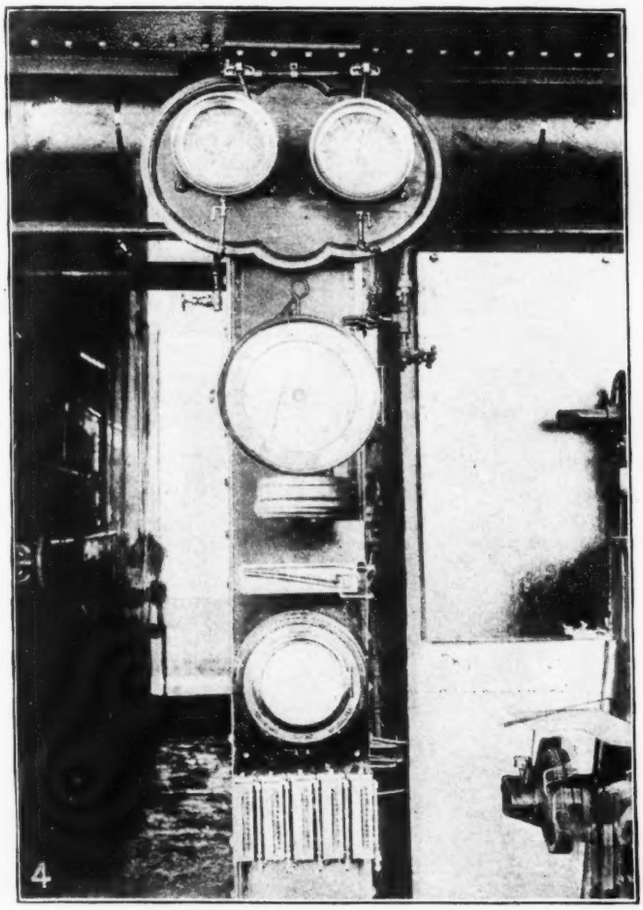
FIG. 3. TUBULAR WASTE-HEAT SUPERHEATER

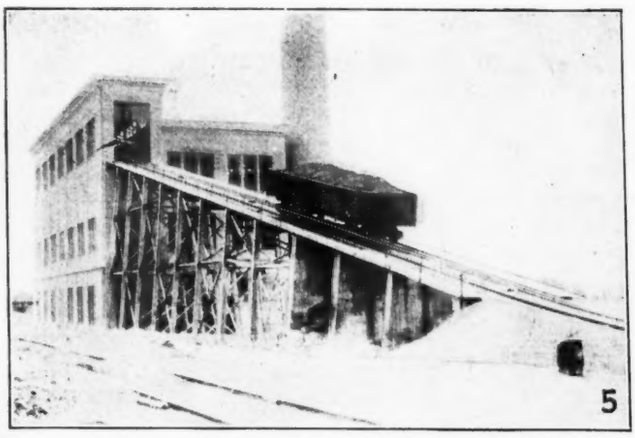
mine until it is discharged as ash, the latter operation being into railway cars, and if it is desired to unload the ash on the premises, a locomotive crane serving both the plant and the mine is available for the purpose.

The coal for power plant use is crushed at the mine and is conveyed to the station in standard railway cars pulled by an electric locomotive owned by the company. At the plant these cars are pulled up an inclined trestle with a grade of 20 per cent to an elevation above the overhead 800-ton steel bunker serving the four boilers. See Fig. 5. The motive power in this case is supplied by a 50-hp. slip ring induction motor geared to a hoisting drum. A safety device, commonly known as a "goat," is coupled to the rear of the car and follows it up to prevent accident in case the hoisting cable should break. The railway track continues over the bunker top and from bottom dump cars the coal is discharged directly into the bunker. The hoist is large enough to take two 50-ton cars up the incline, but as a rule only one car is pulled up at a time. The round trip requires about 30 min., so that with one car operation, the equipment has capacity to deliver 100 tons of coal per hour, and with two cars the capacity is doubled. Triple spouts with sliding gates lead from the bunkers to each stoker, the arrangement being shown plainly in Fig. 1.

The water supply for the plant is obtained from an artificial lake, covering about 35 acres of ground and holding 90,000,000 gal., which was formed by damming up a wet weather creek. The concrete dam is about 600 ft. long and 18 ft. high at the center. From the deepest point at the center of the dam a flume leads to two cold wells under the condenser floor, one for supplying water to the condensers and the other to supply boiler feed water. From the cold well the feed water is forced through four cast-iron cooling sections placed two on either side in the furnace walls to prevent clinker adhering to the brickwork and through a water back at the rear of the furnace. These four sections, each 8 in. square, and the water back are connected in multiple to the supply header through ¾-in. lines, so that if one section becomes clogged or out of service in some way, the others will continue to function. The water enters at the bottom and discharges at the top of the section, the various outlets being connected to a 3-in. line which in turn delivers to a 6-in. main receiving the water from the four boilers and discharging it to either one of two feed-water heaters, each having a capacity of 250,000 lb. per hour. Hand valves on the various supply lines to the cooling sections and to the water back permit regulation of the supply and any surplus may overflow from the heaters back to the lake. As the quantity of water passing through the cooling sections is comparatively large, its temperature during the colder months does not exceed 84 deg. by the time it reaches the feed-water heater. By the exhaust from the various pumps, stoker engine and the stoker blowers, the temperature is raised to 175 deg. in the heater and at this temperature is fed to the boilers.

In case that sufficient feed water is not passed through the furnace cooling sections, a provision has been made to automatically supply the deficiency. Any





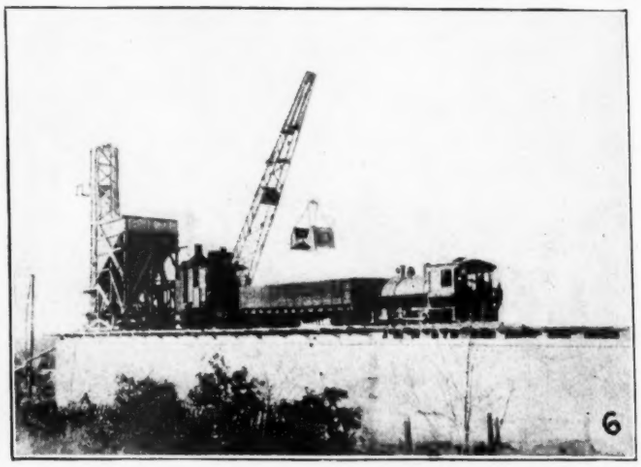


FIG. 4. INDIVIDUAL BOILER INSTRUMENT PANEL. FIG. 5. COAL CAR PULLED UP INCLINE TO OVERHEAD BUNKER. FIG. 6. BUILDING CONCRETE DAM TO FORM ARTIFICIAL LAKE

one of three auxiliary make-up pumps with suction connection to the cold well, are kept under steam pressure and may be started or stopped by the pump governor under the control of an automatic float valve in the heater. At present a surplus of water is available, but as the load increases there may be need for the auxiliary pumps mentioned. The two heaters are located on a platform between the first and second floors, so that they may supply the boiler feed pumps under head. Of the latter there are three of the reciprocating type which discharge to the boiler under hand control. An 8-in. feed main and an auxiliary 6-in. line for feeding or washing have been provided. The pumps are connected to both mains and their services may be divided between them.

In the turbine room there are three machines, two rated at 2,500 kw. and one at 1,250 kw. at a power factor of 80 per cent. Each machine delivers three-phase, 60-cycle current at 6,600 volts and the speed in each case is 3,600 r.p.m. The three units have reinforced-concrete foundations which rest on piling driven to hardpan. Spacing around the foundation 1 in. wide separates it from the floor, so that the machines are isolated and there is no opportunity to transmit vibration to the building construction.

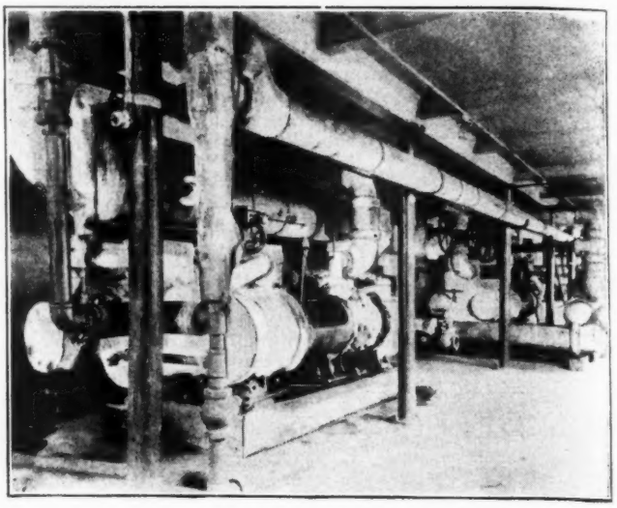


FIG. 7. BOILER-FEED PUMPS

Each turbine is served by a jet condenser, the larger machines having condensers of the 16-in. double-runner, submerged type, with a water removal pump capacity of 3,800 gal. per min. The smaller unit has a 12-in.

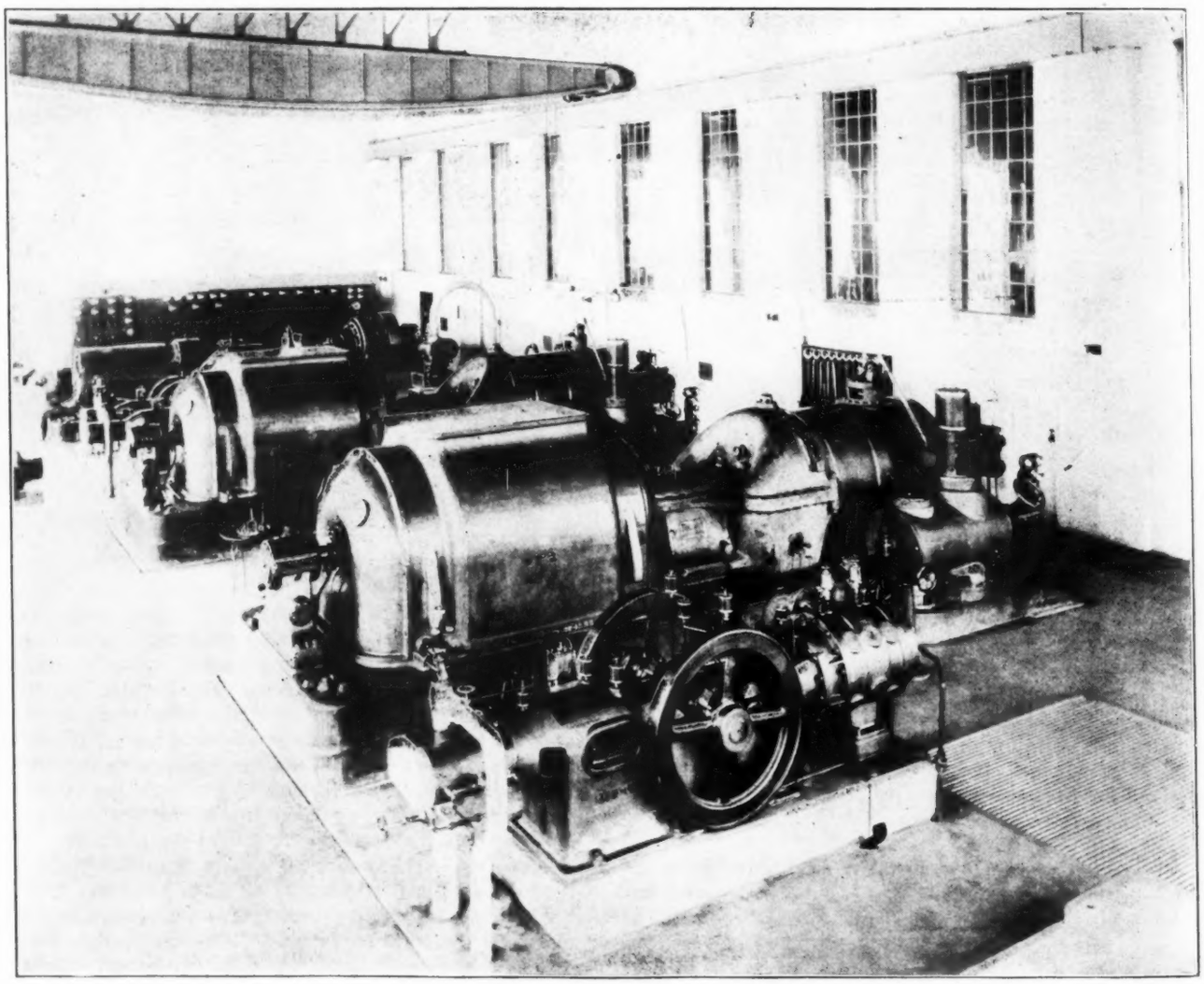


FIG. 8. PRESENT EQUIPMENT OF TURBINE ROOM

single-runner jet condenser with a pump capacity of 1,900 gal. per min. The dry vacuum pumps, which are of the reciprocating type, are located on the turbine-room floor.

For the most part the electrical load is made up of induction motors, the large motors driving the hoists and the ventilating fans are of the slip-ring induction

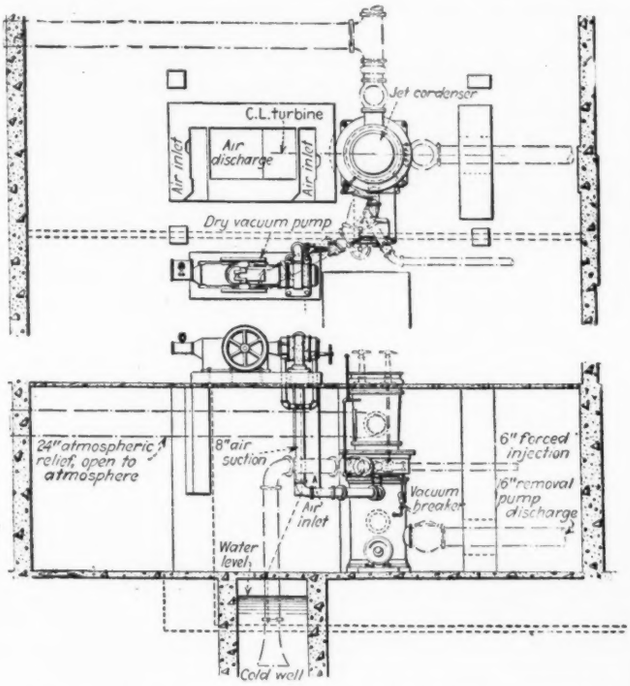


FIG. 9. PLAN AND ELEVATION SHOWING LAYOUT OF CONDENSER AND AUXILIARIES

type with liquid rheostat control. These larger motors are designed for 2,200 volts, but for the smaller motors and for lighting the voltage is reduced to 220-110 volts. To offset the lag in the current caused by the induction motor load, a number of synchronous motors have been installed, principally in connection with motor-generator sets at the mines supplying direct current for charging the batteries and for mine haulage. Under normal conditions a power factor of 90 per cent is obtained, and when charging the batteries, the power factor runs up to unity.

To the Schoper mine, current is transmitted at generator voltage and at the mine is stepped down to 2,200 volts for the motors driving the hoists and the ventilating fans. In a substation down in the mine, the 2,200 volts is reduced to 220 through a synchronous motor-generator set to supply the direct current needed. For transmission to the Berry and Carlinville mines, 9 miles distant, the voltage is stepped up to 33,000, and at the receiving end is stepped down to 2,200 volts for the large motors and to 220 volts direct current for the other services, as mentioned.

Excitation is supplied by four exciter sets, two of 15-kw. capacity and two rated at 75 kw., one of each pair being steam driven and the other directly connected to an induction motor. The motor-generator sets are used when the plant is in operation and the steam sets for starting up.

A switchboard of standard construction and equipment has been placed at the end of the turbine room.

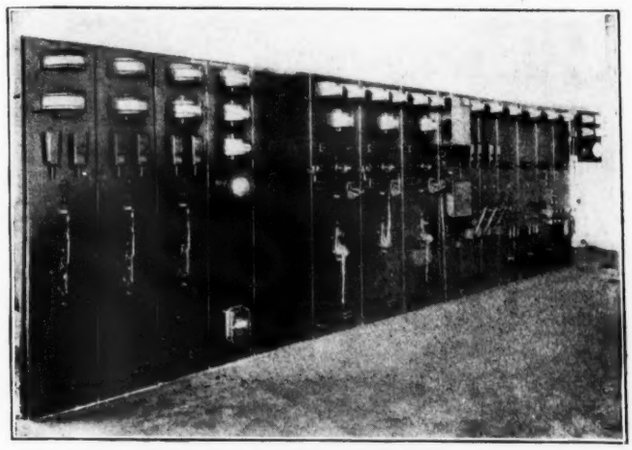


FIG. 10. MAIN SWITCHBOARD OF PLANT

The oil switches, buses and transformers are located on the floor below and at the same level is a standard outdoor substation serving the Berry transmission line.

A. P. McCormick, chief engineer at the Wood River plant, is responsible for the design of the power station under description. The operation of the plant is under the supervision of C. W. Clark, who is assistant manager of the mining property.

PRINCIPAL EQUIPMENT OF STANDARD OIL PLANT AT SCHOPER, ILL.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Water-tube	5,000 sq.ft.	Generate steam	170 lb., 100 deg., superheat, forced draft	Henry Vogt Machine Co.
4	Superheaters	Tubular		Serve boilers	Located in last pass	A. P. McCormick
4	Stokers	Forced-draft ch. grate	120 sq.ft.	Serve boilers	Five zone, five blowers	Illinois Stoker Co.
2	Engines	Vertical	6x6-in.	Drive stokers	Under control of damper regulator	American Blower Co.
2	Pumps	Reciprocating	10x16x8½x10 in.	Boiler feed		Worthington Pump & Mach. Corp.
1	Pump	Reciprocating	14x8½x10 in.	Boiler feed		Worthington Pump & Mach. Corp.
3	Pumps	Reciprocating	6x9x7x10 in.	Auxiliary make-up		Worthington Pump & Mach. Corp.
1	Pump	Reciprocating	12x18x14x12 in.	Service		Worthington Pump & Mach. Corp.
1	Pump	Reciprocating	14x14x12 in.	Service		Worthington Pump & Mach. Corp.
2	Heaters	Open	250,000 lb. per hr.	Heat feed water	Exhaust steam, water 84 to 175 deg.	Harrison Safety Boiler Works
1	Hoist	Electric	200 tons per hr.	Pull Ry. cars over bunker	Geared to G.E., 50-hp. ind. motor	Lidgerwood Mfg. Co.
2	Turbines	Parsons	2,500 kw.	Main generating unit	160 lb. steam, 100 deg., superheat, 3,600 r.p.m.	Allis-Chalmers Co.
2	Generators	A.C.	2,500 kw.	Main generating units	6,600 volts, 3-phase, 60-cycle, 3,600 r.p.m.	Allis-Chalmers Co.
1	Turbine	Parsons	1,250 kw.	Main generating unit	160 lb. steam, 100 deg. superheat, 3,600 r.p.m.	Allis-Chalmers Co.
1	Generator	A. C.	1,250 kw.	Main generating unit	6,600 volts, 3-phase, 60 cycles, 3,600 r.p.m.	Allis-Chalmers Co.
2	Condensers	Jet	16-in. dble. runner	Serve 2,500 kw. turbines	Dr. by 85-hp. Ind. motor, 1,160 r.p.m.	Allis-Chalmers Co.
1	Condenser	Jet	12-in. sgl. runner.	Serve 1,250-kw. turbine	Dr. by 40-hp. Ind. motor, 1,160 r.p.m.	Allis-Chalmers Co.
2	Air pumps	Dry	8x18x12 in.	Serve condensers 2,500 kw. unit		Allis-Chalmers Co.
1	Air pump	Dry	6x15x10-in.	Serve condenser, 1250 kw. units		Allis-Chalmers Co.
2	Exciters		75-kw.	Excitation main units	One driven by 12x13 in. Ideal eng.; one ind. motor-driven	Allis-Chalmers Co.
2	Exciters		15-kw.	Excitation main units	One dr. by A.B.C. 7x7-in. engine; one ind. motor driven	Allis-Chalmers Co.
3	Transformers	Oil-cooled	150 k.v.a.	Power to large plant motors	6,600-2,200 volts	General Electric Co.
1	Crane	Hand-operated	20-ton	Serve turbine room		Whiting Fdry. Equipment Co.

Coppus blowers for stokers; Defender damper regulators; Defender differential draft gages; Defender U-tube draft gages; G.E. flow meters; Hoskins recording pyrometers; Marsh pressure gages; McMyler locomotive crane, 2-ton bucket; Bayer soot blowers; Foster automatic stop and non-return valves; Crane steam and water valves; Everlasting blow-off valves; Crosby safety valves, Allis-Chalmers switchboard with Wagner and Westinghouse meters and G.E. circuit breakers.

Steam Flow Measurements from a Boiler

By C. T. Mitchell*

Momentary readings of the steam flow records from an individual boiler are apt to be misleading. The operating engineer glancing over the chart is surprised to note that a certain boiler occasionally reaches 200 per cent rating when he had thought the boiler not good for much over half that capacity. Similarly, draft or temperature readings taken simultaneously with steam flow readings may later prove, for some reason or other, to be entirely useless.

If an eye were kept on the rate of steam-pressure variation in the boiler, while the other readings were being taken, the reason for many discrepancies would be discovered. When a boiler that is not responsive to load variation receives a sudden demand for steam, it can, of course, supply this demand only at a sacrifice of pressure. The following is an attempt to point out the importance of constant pressure as regards the accuracy of steam-flow records, and to develop a simple formula for calculating the amount of steam given off by a boiler for a given pressure drop, independently of the fuel consumption:

Let h_1 = total heat in one pound of water in boiler at higher pressure;

h_2 = total heat in one pound of water in boiler at lower pressure;

H_1 = total heat in one pound of steam in boiler at higher pressure;

H_2 = total heat in one pound of steam in boiler at lower pressure;

W = pounds of water in boiler before release of steam;

S = pounds of steam released due to drop in pressure.

Then Wh_1 = total heat in water in boiler before release of steam;

$(W - S)\ h_2$ = total heat in water in boiler after release of steam;

$Wh_1 - (W - S)\ h_2$ = total heat in steam released;

also $S\ \frac{(H_1 + H_2)}{2}$ = total heat in steam released (this expression being not mathematically correct, but sufficiently accurate for such pressure drops as occur in practice).

Whence $$S = \frac{W(h_1 - h_2)}{(\frac{1}{2})\ H_1 + (\frac{1}{2})\ H_2 - h_2}$$

On reference to the steam tables it is seen that H_1 and H_2 are so nearly alike for ordinary pressure drops that the difference between them may be neglected. The denominator of this equation then becomes an expression for the latent heat of steam at the lower pressure. For simplicity, let this be denoted by L_2.

The quantity $h_1 - h_2$ in the numerator is virtually the temperature difference between the water at the higher and lower pressures. Let this difference be denoted by T and the formula becomes quite simple and sufficiently accurate.

$$S = \frac{WT}{L_2}$$

S being the amount of steam or "flash" corresponding to a given pressure drop. To express the steam in pounds per hour the element of time must be introduced. Let m equal the number of minutes required for the drop in pressure. Then

$$S \text{ per hour} = \frac{60\ WT}{m\ L_2}$$

This equation is, of course, true only when the water in the boiler is all at the boiling point before the pressure drop occurs. But this discussion is only for the purpose of pointing out what the possible variations from the steam flow record *may* be, and it is quite conceivable that all the water in the boiler often is at the boiling point, except immediately after the admission of a large quantity of feed water. Even then it is difficult to imagine that more than a few seconds are consumed in bringing the inflowing water to the boiling point, in view of its immediate contact with innumerable bubbles of ascending steam.

Now to illustrate by an example the effect of pressure drop on the flow of steam, consider a water-tube boiler having 5,000 sq.ft. of heating surface and containing 40,000 lb. of water. Suppose, at a sudden call for steam, the boiler pressure drops from 165 to 160 lb. absolute in one minute, which is not an unusual occurrence. Substituting the proper values from the steam tables in the equation, we find that

$$S = \frac{60\ WT}{m\ L_2} = \frac{60 \times 40{,}000 \times 2.4}{1 \times 858.8} = 6{,}700 \text{ lb. per hr.}$$

As this is equivalent to nearly 50 per cent of the normal rating of the boiler, it is evident that little dependence may be placed on a momentary reading of the chart as an indication of the actual performance of a boiler, unless there is absolute certainty of constant pressure. When the pressure recovers, the chart reading will be correspondingly low until a balance is again reached.

In addition to the flash from the water in the boiler, there is a flow from the steam storage in the top of the drums during pressure drop. This is too small, however, to influence the chart reading to any great extent, as may be demonstrated by a little simple figuring.

*Mechanical Division, the J. G. White Engineering Corporation.

The modern blast furnace gas engine shows much greater reliability and a somewhat higher thermal efficiency than formerly, but the steam turbine plant, when high pressures and superheat are used and all auxiliaries such as gas washers are taken into consideration, runs a pretty close second in regard to economy and can be installed at a much lower figure. However, all of the possibilities of the gas engine have not been taken care of, although some work has been done along this line in this country and considerable in Europe. By utilizing the heat of the exhaust and of the jacket water the thermal efficiency of the entire system can be made at least double that of the engine alone. In one plant in the United States the exhaust is to be used to run a high pressure boiler; in Germany low pressure boilers and low pressure turbines are used to some extent. In another plant 1,000 B.t.u. for each kw.-hr. output of the gas engine units are obtained by a very simple and inexpensive air heater, which is used to heat the buildings and which increases the back pressure on the engine less than two inches of water. However, this last is only used in winter and could be made more effective, as up to 3,000 B.t.u. are available from the exhaust.—*The Blast Furnace and Steel Plant.*

Generator Operating Temperatures

The Three Classes of Insulation Employed to Protect the Windings of Electric Generating Machines—Operating-Temperature Limits—Methods Used to Determine Accurately These Temperatures

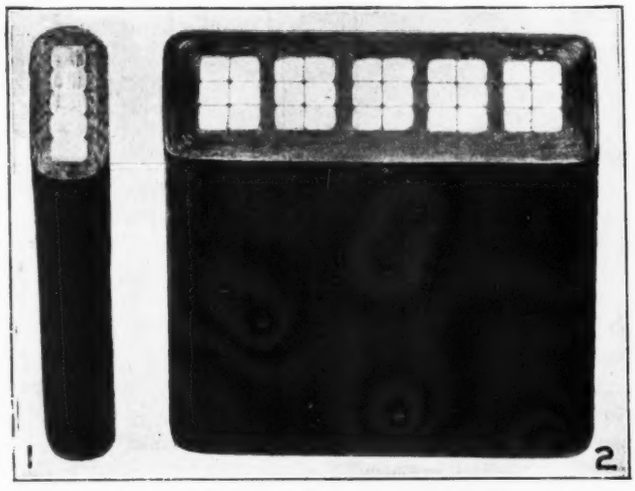
By S. H. MORTENSEN
Electrical Engineer, Allis-Chalmers Manufacturing Company

ONE of the main factors determining the life of an electrical machine is the temperature to which its insulation is subjected. If this temperature is kept below a certain critical value, depending upon the character of the material, any further reduction in the operating temperature will not materially increase the longevity of the insulation. On the other hand, if the critical temperature limit is exceeded, deterioration becomes rapid and the insulation suffers permanent damage to an extent depending upon the excess of the temperature as well as upon the length of time it prevails.

In the construction of electrical machines the insulating materials commonly used can be subdivided into three main classes which, in the following, will be designated as A, B and C:

Class A comprises cotton, silk or paper whose thermal limits have been increased either by impregnation or similar treatment or by permanent immersion in oil. To this class also belongs enameled wire. The maximum temperature to which Class A insulation may be subjected should not exceed 105 deg. C.[1] (221 deg. F.).

Class B includes mica, asbestos and other materials capable of resisting high temperatures in which any Class A material or binder is used for structural purposes only and in such a way that it may be destroyed without impairing the insulating or mechanical values of the insulation. For this class of insulation the temperature is at present limited to 125 deg. C. (257 deg. F.), although it is recognized that Class B insulation properly composed can safely withstand operating temperatures up to 150 deg. C. (302 deg. F.) continuously. However, where this temperature limit is specified, the manufacturer gives special guarantees covering the operation at 150 deg. C. (302 deg. F.).



FIGS. 1 AND 2. COILS INSULATED WITH DIFFERENT CLASSES OF INSULATION
Fig. 1—Class A insulation. Fig. 2—Class B insulation.

[1]Standard Rules A. I. E. E.

Class C insulation consists of pure mica, porcelain, quartz and similar material capable of resisting higher temperatures than Class B. No definite temperature limit has yet been fixed for this class of material.

In the construction of the stator and rotor coils of electrical machines the insulating material used is either Class A or Class B or a combination of the two, and their maximum operating temperatures are thus limited to 105, 125 or 150 deg. C., respectively. An example of Class A insulation is shown in Fig. 1, and Fig. 2 shows a section through a coil with Class B insulation.

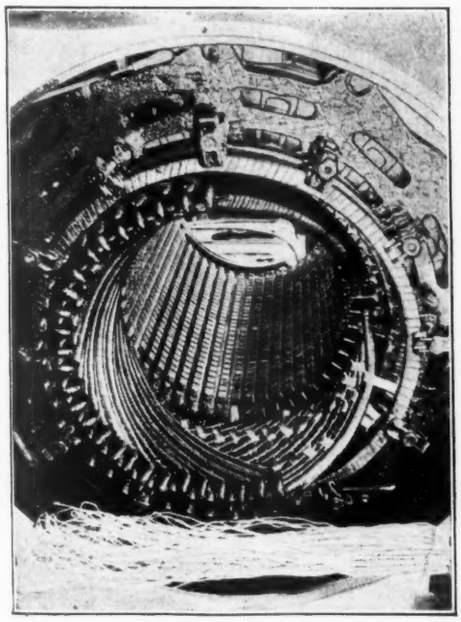


FIG. 3. TEMPERATURES VARY IN MACHINES OF GREAT AXIAL LENGTH

In machines of long axial length, such as is shown in Fig. 3, the temperature rise varies on account of the difficulties involved in ventilating uniformly the different parts. In such machines it is common practice to use Class B insulation on the parts whose temperatures exceed 105 deg. C. (221 deg. F.) and Class A insulation where the maximum temperature is within this limit. From Fig. 3 it is apparent that the cooler portions of the stator coils are the free ends, which are subjected to more effective ventilation than the portions of the coil embedded in the stator iron. In machines of this type the embedded parts of the coils are, as a rule, covered with Class B insulation and the ends with Class A insulation.

A combination of Class A and Class B insulation may be used on coils with a high temperature gradient through the insulating wall, Class B being used adjacent to the heated conductors and for that portion of the insulation whose temperature exceeds 105 deg. C. (221 deg. F.) and Class A for the balance.

From the foregoing the importance of determining the maximum operating temperatures of electrical machines is apparent, and for that purpose three methods are at the present time in use; namely, the thermometer, the increase-in-resistance method and the embedded-detector method. The maximum temperature determined by any one of these methods is called the observable temperature and may or may not be the maximum or hot-spot temperature actually developed in the machine. Taking this into consideration, safe operation requires that the observable temperature be a certain amount less than the permissible hot-spot temperature, and this is called the conventional allowance, or hot-spot correction. Based on the experience gained on machines in operation combined with laboratory tests, the Standardization Rules of the American Institute of Electrical Engineers make definite recommendations for the conventional allowances applicable to the different methods of measurement. The conventional allowances corresponding to the three methods given appear in Table I.

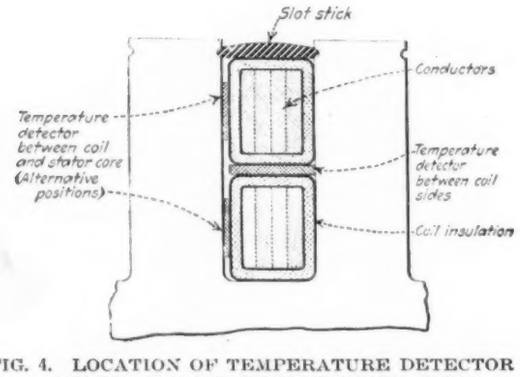


FIG. 4. LOCATION OF TEMPERATURE DETECTOR IN STATOR HAVING DOUBLE-LAYER COILS

TABLE I. CONVENTIONAL ALLOWANCES OVER OBSERVABLE TEMPERATURES

Method of Measurement	Conventional Allowance
1. Thermometer, deg. C	15
2. Resistance, deg. C	10
3. Embedded detectors:	
With double-layer coils, as shown in Fig. 4, deg. C	5
With single-layer coils for machines under 5,000 volts, as shown in Fig. 5, deg. C	10
With single-layer coils, for machines over 5,000 volts, as shown in Fig. 5, deg. C	10+ (E-5)

Where E = Rated terminal voltage in kilovolts.

To standardize the maximum observable temperature rise permissible in electrical machines, it is necessary to fix a value of reference. This value is commonly referred to as the ambient temperature of reference and is the temperature of the air which, by coming into contact with the heated parts of the machine, carries off its heat. The standard rules of the A. I. E. E. fix this temperature at 40 deg. C., and the maximum observable temperatures given in Table II are derived by subtracting the sum of the ambient temperature of reference and the conventional allowance from the maximum operating temperatures permissible for Class A and Class B insulation.

Temperature measurements by thermometer are taken by means of mercury, alcohol or resistance thermometers or by thermocouples placed on the hottest accessible portion of the completed machine. These methods give reliable results when applied to open-type machines of comparatively short axial lengths, but are less reliable on high-speed machines of compact construction where large temperature variations exist between the accessible and the inaccessible parts.

The resistance method of temperature measurements is based on the increase or decrease of the electrical resistance of the windings of an electrical machine with the corresponding changes in temperature. This method gives the average temperature of the complete winding, but does not give the hot-spot temperatures. It is widely used for determining the temperature of the rotating field, where it is impractical to install detectors. It also serves as a check on temperature readings, obtained by methods 1 and 3 of Table I and should be used in conjunction with either of these methods wherever possible. The highest temperature value obtained is to be taken as the observable temperature.

TABLE II. MAXIMUM OBSERVABLE TEMPERATURES

Method of Measurement	Class A, 105 Deg. C.	Class B, 125 Deg. C.	Class B, 150 Deg. C.
Thermometer, deg. C	50	70	95
Resistance, deg. C	55	75	100
Embedded detector:			
Coils as in Fig. 4, deg. C	60	80	105
Coils as in Fig. 5, under 5,000 volts deg. C	55	75	100
Coils as in Fig. 5, over 5,000 volts, deg. C	55—(E-5)	75—(E-5)	100—(E-5)

E = Rated terminal voltage in kilovolts.

Temperature measurements from embedded detectors supplement methods 1 and 2 and also provide a means for obtaining a continuous record of the hot-spot temperature of the machine during its regular operation. This method utilizes thermocouples or resistance coils in conjunction with indicating or recording instruments. The couples or coils are located in the estimated hottest portion of the stator winding when the machine is constructed. According to the rules of the A. I. E. E., detectors should be provided in machines whose core lengths exceed 20 in. and in all machines whose voltage exceeds 5,000, provided their capacity exceeds 500 kva. These rules also recommend the location of the temperature detectors in the stator slots, as indicated in Figs. 4 and 5. To make sure that the detectors actually register what is approximately the hot-spot temperature of the winding, the results obtained should be checked by methods 1 and 2 and the maximum temperature thus obtained, after the proper corrections are made, is then the observable temperature. As considerable variation exists between the temperatures in various locations in large machines, it is difficult to predetermine just where the hot spot will be in a new machine, and for that reason it is common practice to install a large number of detectors uniformly throughout the winding of such machines and then be guided by the detector that shows the maximum temperature.

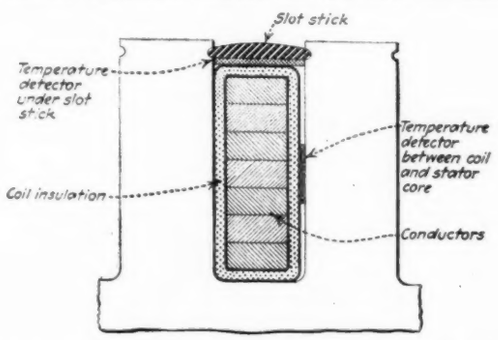


FIG. 5. LOCATION OF DETECTOR IN STATOR WITH SINGLE-LAYER COILS

Keeping Records in the Refrigerating Plant

By N. DRUIN

EVEN though the entire world is striving for lower manufacturing costs, in many power plants the operating forces are not aware of the possibilities of increasing the plant efficiency. Probably in no branch of power-plant engineering does this hold so true as in the average refrigerating plant. The refrigerating engineer usually feels that, where the plant possesses its own boiler room, the opportunities of securing better results are in the boiler room above. If the engineer is ambitious, he will spend a good deal of time with his firemen and will insist on proper boiler and furnace. On the other hand, too many think that the refrigerating end of the plant needs only enough attention to keep it running. If the machine is motor-driven it is often considered as being practically automatic, and so no steps are taken toward securing the maximum refrigerating results with the least electrical consumption.

For example, in too many refrigerating plants the suction pressure of the system is kept entirely too low. If only one compressor is installed, of course the suction pressure in the system must be the lowest required by any part of the refrigerating system, such as a sharp freezer. Where it is possible to operate two machines, the low-temperature work should be handled by one machine and the medium-temperature rooms by the other. Many plants are losing thousands of dollars by carrying suction pressures and temperatures below those demanded. Suction gas at a low pressure has less density than a higher-pressure gas. The compressor handles less ammonia by weight per minute. For a given speed the compressor capacity is reduced. The horsepower of the compressor is less, but the lowered capacity more than counterbalances the reduction in horsepower. With suction pressures of 15 and 30 lb. the loss is about 25 per cent. Likewise, at the end of compression the temperature with high suction is somewhat less than with low suction pressure. Consequently, the condenser temperature is lower with less likelihood of danger from oil vapors, etc. A study of the subject shows the advisability of as high suction pressures and as low condenser pressures as possible.

That more attention should be given to these details was strikingly illustrated in a plant that came under my care. When I took charge the engineer knew nothing about the cost of operation either on a daily or a cubic foot of cold storage basis. Neither were any records kept as to the temperatures and pressures carried in the several parts of the system, which consisted in the main of beef coolers and freezers.

The main office, of course, kept accurate record of the cost of storaging beef, the plant being a meat storage; but not being in personal contact with the plant, the management did not know nor could it find out if the plant was actually being operated efficiently. The machine end of the plant consisted of two 15-ton compressors belt-driven by two direct-current 220-volt motors. The current was purchased from the central station at a rate of 3c. per kw.-hr. for the compressor, 5c. for elevator motors and 8c. for lighting requirements. Steam boilers were used for heating, meat-boiling purposes, etc.

Upon taking charge, I immediately secured a cheap composition book and used two or more pages a month. In this book I put down all items of expense incurred during the month. All invoices for plant supplies came to me for an O.K., and I had no trouble in getting each item of expense. The coal cost was entered as received. This of course did not make an accurate monthly check, but the yearly total was always correct. The electric-power bill was likewise entered as received, and checked against the several meter readings.

The first year I made many changes which lowered the cost of operation, but not having the costs for the preceding year, no comparison can be made. The second year the improved efficiency over my first year was easily found. More attention to the temperatures carried in the beef cooler and freezer rooms enabled a far greater tonnage to be carried at but slightly greater power consumption. As shown in the table for 1918, the compressors used 5,800 more kilowatt-hours than in 1917, costing $174, but practically twice the amount of beef was handled, giving 50 per cent increased refrigeration at less than 10 per cent machine power increase. The lighting load was heavier in 1918, since handling of the large amount of storage required the use of much more lighting in the rooms.

The refrigerating system was operated far more efficiently. This was solely a matter of controlling the suction and head pressures and temperatures. We

TABLE I. DAILY LOG OF REFRIGERATING TEMPERATURES FOR AUGUST

Date	Beef Cooler	Bunker	S. P. Meats	Eggs	Freezer	Head Press.	Back Press.	H. M. Runs	Cond. On	Cond. Water Off	Outside Atmos.	No. of Mach. Run	Kw.	Coal, Lb.	Steam Press.
1	33	33	33	38	13	195	20	13	78	87	79	2	430	0	60
2	33	33	32	38	12	180	20	15	76	85	80	2	410	0	60
3	33	33	34	37	18	195	20	13	85	95	93	2	450	350	0
4	33	33	32	37	16	195	20	15	86	96	81	2	460	350	60
5	33	33	33	38	20	195	20	17	84	93	88	2	500	350	60
6	32	33	34	38	16	190	20	22	81	90	80	2	650	350	60
7	32	32	35	38	14	195	20	19	84	93	87	2	550	350	60
8	32	33	34	37	12	190	20	19	80	90	81	2	500	350	60
9	31	32	32	38	12	195	20	15	82	91	85	2	450	350	60
10	30	30	33	38	12	190	20	14	80	90	86	2	400	0	0
11	30	30	34	38	12	190	20	13	78	87	82	2	410	350	60
12	30	30	33	37	12	195	20	8	76	85	80	2	250	0	60
13	30	30	34	37	12	190	20	11	75	84	77	2	330	350	60
14	30	30	33	38	12	190	20	15	74	82	75	2	440	350	60
15	30	30	34	38	18	190	20	17	78	87	80	2	470	350	60
16	30	30	33	36	18	190	20	18	79	88	82	2	480	0	60
17	31	31	32	37	17	170	20	14	72	80	75	2	350	0	0
18	31	32	32	37	16	175	20	17	74	82	77	2	440	700	60
19	31	31	34	38	15	180	20	19	77	86	80	2	560	350	60
20	30	31	33	37	13	190	20	18	78	87	80	2	510	0	60
21	30	30	34	35	12	190	20	18	76	85	83	2	500	0	60
22	30	31	33	36	12	190	20	12	78	87	85	2	400	0	60
23	30	31	34	36	12	190	20	14	78	87	86	2	390	0	60
24	30	30	32	36	12	190	20	20	80	89	90	2	600	0	0
25	31	31	33	36	12	175	20	6	72	80	78	2	170	350	60
26	31	32	34	37	12	175	20	6	72	81	75	2	190	350	60
27	31	31	33	36	12	175	20	9	70	78	70	2	310	350	60
28	31	31	34	37	12	175	20	8	70	79	72	2	210	350	60
29	31	32	33	36	12	175	20	8	72	80	73	2	230	350	60
30	31	31	34	37	12	185	20	7	75	84	75	2	200	0	60
31	30	30	32	36	12	185	20	8	76	85	78	2	240	0	0
Ave.,	31.00	31.29	33.23	37.03	13.61	186.61	20.00	13.80	77.29	86.22	80.42	2	402.59	210.52	50.32

found that the rooms could be carried at a higher temperature than formerly was allowed. We also made it a practice to stop the machine as soon as the temperatures in the rooms were below the desired amount, starting up again when the temperatures rose fifteen to twenty degrees. This avoided the losses due to low suction pressures. Increasing the efficiency of the condensers by keeping the coils clean lowered the head pressure and decreased the amount of water circulated. In the storage rooms the direct expansion system was employed. The coils accumulated a large amount of frost. In former years this gathered until it was three or four inches thick, it being thought that the increased area of the frost actually increased the rate of heat transference. We got into the habit of scraping the coils as soon as the frost started to accumulate, allowing 5 to 10 deg. greater coil temperature to be carried, since with the frosted pipe the temperature drop was often twenty degrees.

In 1919 the compressor power demand per ton of products handled was lowered a considerable amount since a large tonnage of butter was carried in 1919. Table I shows a record of the temperatures and pressures carried during August, 1919. This chart gives an idea of the records that should be kept in any cold-storage plant. All the comparative figures should assist the engineer to see the advantage of keeping a record of all expense and refrigerating output. It was of course practically impossible to keep any record of the length of time each beef shipment remained in cold storage. However, most of it when received was fairly low in

TABLE II. OPERATING COSTS OF REFRIGERATING PLANT

Year	1917	1918	1919
Electrical supplies	$346.21	$188.95	$384.16
Plumbing supplies	44.50	90.16	40.74
Plumber labor	142.25	.....	73.70
Hardware	141.59	106.78	22.00
Repairs	20.79	.....	62.78
Oil and boiler compound	48.56	64.68	64.27
Coal	996.84	1,265.59	324.15
Ash handling	33.24	27.35	42.00
Ammonia	108.00	112.44	128.00
Compressor supplies	43.69	33.91	139.15
Cement for lights	1,428.48	1,698.72	1,834.32
Current for elevators	169.50	98.50	95.50
Current for compressor	2,132.70	2,366.70	2,593.80
Engineers' salary	1,459.32	1,717.12	1,950.08
Rent for machine room	1,309.20	1,309.20	1,309.20
Total operating cost	8,324.87	9,080.10	9,045.85
Refrigeration cost per cubic foot cold storage	$0.0506	$0.0549	$0.0545
Beef in freezers, lb.	414,031	820,395	715,546
Box meats, lb.	.....	.....	1,797,730
Meats in coolers, lb.	.....	20,325,465	21,238,435

temperature and the greater part of the refrigerating duty was devoted to removing the heat coming in through the walls and doors. The tabulation of costs shows that in 1918 and 1919 the cost per cubic foot of cold storage was 5.49c. and 5.45c. respectively. In 1917 the cost was 5.06c., although the 1918 operation was more efficient than the 1917 record. It is probable that the reduction was over 20 per cent. On this basis doubling the amount of beef handled increased the cost per cubic foot approximately 30 per cent. From this may be deduced the thought that the construction of cold-storage walls and the design of doors, etc., influence the duty required from the plant far more than is generally understood.

I have come to the conclusion after two years of experience derived from my official position, that coal, which is the very basis of our life, should be under the complete control of the Federal Government, and perhaps a more efficient way of handling it would be for the United States to control and operate the coal mines.—*Governor J. J. Blaine, of Wisconsin.*

Bronze for Bearing Metal

By E. T. Keenan

One often hears an engineer say, "This is a good piece of brass," and quite possibly what he refers to is not brass at all, but bronze. The Standard Dictionary defines brass as "a yellow alloy of copper and zinc" and bronze "an alloy of copper, tin and zinc," though practice gives several kinds of bronze, such as manganese bronze, tobin bronze, statuary bronze, phosphor bronze, etc. There is also yellow metal such as bell brass, car brass and cadmium brass.

A metal that is good for one usage is not good for another. This article will deal with good brass or bronze from the standpoint of a bearing metal. All such metal of a bronze or brass nature will have copper as a base to which will be added other metals. The question arises what other metals, and it can be answered only by knowing what service the metal will be subjected to and what it is expected to do.

Bearings are subjected to various tasks and operate under various conditions, some favorable and some severe. In power-plant environments the conditions can be reduced to a few demands, as for instance; electric-motor bearings, stationary-engine journals, centrifugal-pump bearings, crosshead bearings, and crankpin bearings.

These various bearings operate under the following conditions:

1. Electric-motor bearings: High speed, no pound, good and constant lubrication, liberally proportioned bearings as per weight per square inch and no exterior heat.

2. Stationary-engine journals: Medium speed, some pound, fair lubrication, well proportioned as to weight and good ventilation and radiation.

3. Centrifugal-pump bearings: High speed, no pound, good lubrication, liberally proportioned, good radiation and no heat.

4. Crosshead brasses: Medium speed, some pound, poor lubrication, limited proportions, medium radiation and exterior heat.

5. Crankpin bearings: Heavy pound, intermediate lubrication, great weight and good ventilation.

In analyzing these conditions, it is seen that no two are alike. As copper in itself is not suitable for a bearing metal, a search was made for something to add to it to make it suitable. Tin was the first metal tried, and in the early days copper-tin alloys were invariably used. The most popular was 90 per cent copper and 10 per cent tin. In service where the demand was severe more tin was added. Generally speaking, the harder the metal the more likely it is to heat. Such alloys offered resistance to compression, but cutting was too easily started, so on the whole the copper-tin alloy did not give satisfactory results. Another bad feature was its tendency to grip.

Later, some lead was added, which was found very advantageous, and the popular metal for a long time was the 80-10-10 metal—copper 80, tin 10, lead 10 parts. However, because lead was cheap in comparison with tin, it was generally assumed by those who did not study the performance of the bearing metals they were using, that a fraud was being perpetrated and for a long time considerable opposition was encountered.

In the 80-10-10 alloy difficulties were encountered in the foundry which led, finally, to the copper 77, tin 8 and lead 15 alloy, called experiment B or ExB

metal, which is very much in vogue now. This was the beginning of the practice of decreasing the tin and increasing the lead.

However, the proportion of one metal to another is governed by the requirements of the alloy in respect to its ability (1) to support the load without detortion, (2) to conform to the journal, (3) to withstand shock and (4) to dissipate heat.

Analyzing the different alloys of copper, we have:

1. Copper-tin.—Little more can be said of this alloy than already explained. With less than 24 per cent of tin the bronze can be turned in a lathe without difficulty. Between 24 and 40 per cent tin, it can be cut only with great difficulty. Beyond 40 per cent the brittleness and hardness decrease.

2. Copper-zinc.—Up to 50-50 the alloy is plastic and can be machined. With over 50 per cent of zinc it becomes too brittle to machine.

3. Copper-nickel.—With any proportion of nickel that would tend to make a bearing metal the expense would make it prohibitive.

4. Copper-aluminum.—Aluminum bronzes have practically double the strength of copper-tin. Aside from that they have many of the characteristics of the copper-tin, but on account of foundry difficulties are impractical.

5. Copper-manganese.—This has absolutely no value as a bearing metal.

6. Copper-tin-zinc.—This alloy is extensively used as shown by the following table, gathered from various sources:

	Proportions			Other Materials and Remarks
	Copper	Zinc	Tin	
Admiral metal	87	5	8	For parts of engines on naval vessels.
Bush metal	64	8	4	4 lead, for bearings.
Hard gunmetal	16	1	21½	Heavy bearings.
Phosphor bronze	90	.....		Phosphor tin 10—Cogs, gears, bearings, etc.
U. S. Navy journal boxes and guide gibs	6	.....	1	
Tobin bronze	58.22	39.48	2.30	
Rose metal	64	1	8	
Bronze pieces subject to shock	83	15	1.5	0.5 lead
Eccentric straps	84	2	14	
Bearing metals	89	3	8	
Bearing metals	89	8.5	2.5	
Bearing metals	86	.....	14	
Bearing metals	85¼	2	12¾	
Bearing metals	80	2	18	
Bearing metals	74	9½	9½	½ lead.
Thrust collars	90	.....	10	
Gun metals for high speeds and heavy pressure	88	2	10	
Phosphor bronze for high speed and heavy pressure	80	10	10	
Manganese bronze for propeller blades, valve stems and other parts requiring high strength	56	43½	.....	5 aluminum
	Not good for bearings.			
Plastic bronze	65	.....	5	30 lead.

Plastic bronze is now extensively used and has been tried in the bearings of the heaviest locomotives and found quite satisfactory, not only for driving brasses but for rod brasses.

The principal element of phosphor bronze is in sound castings. A small percentage of phosphorus adds greatly to the ability to make sound castings.

From the foregoing it is evident that the character of the bronze changes as the proportions of the metals are changed, and while one may be a good brass or bronze for one purpose, it is not suitable for another. So do not take an old valve stem to make a bearing bushing and do not take a bearing bushing to make a valve stem. In large plants a penny saved in a pound of bronze amounts to a good deal in the course of a year. Lead is cheaper than tin, so to every pound of tin that can be replaced with lead a saving can be effected. Aim to use the proper material for the job. The first cost of the metal is not the only item, for the labor of preparing it amounts to many times as much. By selecting the right alloy one can also save in replacements, which cost money. Every particle of brass or bronze worn is that much loss. One cannot judge a metal by color; twenty-five per cent of nickel or 18½ per cent of manganese added to copper will remove every trace of red.

The organization with which the writer is connected is now using an alloy consisting of copper 75 per cent, lead 17 per cent, zinc 5 per cent, tin 3 per cent. It gives satisfactory results for general use, machines well and has shown no serious evidence of excessive wear. There will be foundry difficulties in pouring this alloy, due to the high percentage of lead, which is only mechanically held in the alloy; it can be held from settling only by a quick setting of the copper, tin and zinc. By careful handling, a good foundryman can use even as high as 30 per cent lead. By replacing 1 per cent of tin with phosphorus, the mixture might have been improved, as phosphorus improves any bronze by increasing its compressive strength. Antimony in place of tin while adding hardness would have sacrificed ductility and the castings would not be as smooth and might be full of holes.

Compound Generators and Their Adjustment for Multiple Operation

By Eustis H. Thompson

In compound generators, a series field is added to the shunt field in order to increase the magnetism as load is applied, and therefore raise the voltage of the machine as its load increases. Fig. 1 illustrates the arrangement of the field windings in a compound interpole generator. The series-field winding is nearly always shunted with a resistor, as shown in Fig. 1, the length of which can be adjusted at will. The effect is to allow only a portion of the armature current to pass through the series winding, the purpose being to secure

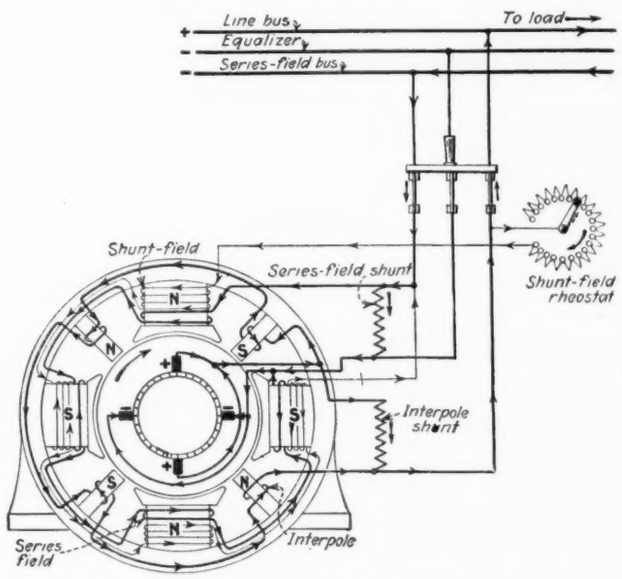


FIG. 1. COMPOUND-WOUND INTERPOLE GENERATOR, SHOWING FIELD CONNECTIONS

Both series-field and interpole windings are shunted with a resistor that is adjusted to divert a certain proportion of the load current.

a fine adjustment of the strength of the series field. This method is often used with interpole winding.

The series field adds a source of instability in multiple operation. When two machines over-compound—that is, supply a higher voltage at full load than at no load—they will not run in multiple under ordinary circumstances without an equalizer. The equalizer, as shown in Fig. 2, is in fact an extra busbar that places all the series fields in parallel. The armatures of the generators feed onto this bus, and this in turn distributes the current to the different series fields in inverse proportion to their resistances, the potential drop across all the series-field windings remaining the same.

It can readily be seen that when an equalizer is not used, in case one machine, while carrying load, should generate a slightly higher voltage than the other one, such as might result from the governor action of its

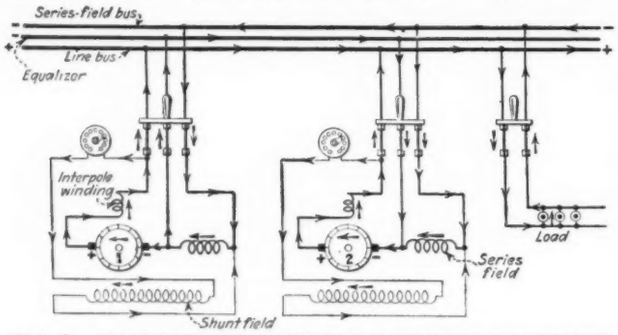


FIG. 2. CURRENT INTERCHANGE BETWEEN COMPOUND GENERATORS IN PARALLEL

Machine No. 2 is supposed to have speeded up slightly and taken more than its share of the outside load. The arrowheads indicate how part of this excess current is drawn through the series field of No. 1, thus raising the terminal voltage of the latter and causing it to take more load. The current through the series field of No. 1 is equal to its armature current plus the equalizer current, while the current in the series field of No. 2 is equal to its armature current minus the equalizer current.

prime mover or a temperature effect in some part of its winding, it would immediately tend to take a trifle more load; this would produce still higher voltage, which would cause the machine to take still more load. This process would continue automatically until the generator had absorbed all the available load and also run the other machines as motors, unless the process was checked by the opening of the circuit breaker or by the limited capacity of the prime mover.

The equalizer prevents such action by returning some of the excess current through the series fields of the other generators, and thereby raises their voltage in order to equalize or divide up the load properly. The interchange of current is indicated in the diagram of Fig. 2. Generator No. 2 is supposed at this particular instant to produce a voltage somewhat higher than generator No. 1, possibly due to the irregular action of the governor or valve gear. It therefore carries more load than No. 1 generator. The drop of potential through its series field would naturally be greater than that of No. 1 generator, on account of its carrying more current. Some of the load current flows through the series field of generator No. 1 and through the equalizer to the brush of generator No. 2, so as to increase the potential drop through the series field of No. 1 until it is approximately equal to that of generator No. 2, since the series fields are in parallel. This strengthens the series field of generator No. 1, and therefore tends to increase its voltage somewhat and make it take a little more load at a slightly lower speed, thus preventing generator No. 2 from taking more than its share.

The adjustment of a generator for multiple operation is usually divided into two parts: (1) Adjustment of the machine itself in accordance with the known conditions of the generating station; (2) placing the generator on the busbars in multiple with the other machines and then making further corrections if necessary to obtain satisfactory operation.

The first part includes the assembly of brush rigging, fitting brushes and making proper connections. Loads should now be applied to the generator itself so that the interpole-field shunt can be adjusted and brushes set to give good commutation; at the same time the series-field shunt can be adjusted so as to give approximately the proper degree of compounding. In cases where a very light compound, such as a flat compound or slightly lower, is desired, only a weak series field should be left active for the purpose of equalizing with the other machines. It is permissible in this case to shift the brushes slightly forward from the mechanical neutral, provided this does not produce any bad effect on the commutation, in order to give the interpole a slight compounding effect opposed to that of the series field, and so secure a fine adjustment of the strength of the latter. The commutating field adjustment should then be made for various brush shifts in order to get an absolute check on this condition, as good commutation is the most essential requirement in adjusting interpole machines.

The machine can now be made ready for operation with the other generators. The voltage drop across the series field and series-field leads should be measured on this machine as well as the other station generators at full load, for it may be necessary to add resistance to the series field in order to make the potential drop the same as in other machines, and so secure correct equalizing with the station generators.

Adjustment of the machine in accordance with the known conditions of the engine room is usually made in the factory. In case it becomes necessary to do this in the plant, it will be found to be of great assistance if an ammeter is placed in the circuit of the adjusting shunt for the interpole field when commutation is adjusted. The results may be plotted in curve form, and the best value of commutating current easily found. The series field can be checked in the same manner. Where difficult cases are encountered and adjustments of this kind are necessary under running conditions, it will be found to be a very satisfactory method.

Many days reports of better business and a better outlook for industry have been appearing in public print. So numerous have been the reports that not a few have regarded them as an effort to stimulate the public confidence essential to resumption of activity. Confirmation of these reports, written in black no less dense than the printers' ink that first recorded them, is visible in Buffalo—the billows of smoke now belching from long idle stacks in industrial sections. To all who dwell in the heart of those districts or passed through or near them in their daily travels, they are a welcome sign. During the fall and winter observers saw them snuffed out, one by one, till scarcely a wisp was visible across many miles. The empty scene, with the knowledge that every idle stack meant scores of idle men, was disheartening. Seeing them once more sending forth their welcome grime is a sight for celebration.—*Buffalo Enquirer.*

Eddy Troubles in an Old French Mill

By ANDRÉ LANDRY

MANY low-head water-power sites in France, some of them of considerable value, are preempted by mills several hundred years old, most of which are of such substantial construction as to discourage all idea of demolishing them to replace them with more modern buildings. Fitting up-to-date hydraulic machinery into these old structures is a difficult undertaking at the best, but a much easier one for American than for French engineers. Whereas the former would ruthlessly cut away all that was not exactly right, the French engineer has an ingrained reverence for the workmanship of the dead and gone and will often stretch a technical point to a dangerous extent rather than cut into the magnificent masonry walls and arches that are to be found in most of these buildings. The following is an instance of trouble due to the fact that the turbine was set too high above the tail-water level, in order to avoid building a new floor for the water chamber.

The turbine was a small 300-hp. machine of the vertical-shaft Francis type, designed for a 7-foot head. The manufacturer had warned the engineers of the probability of eddy troubles, owing to the insufficient submergence afforded by the setting, unless a spiral or parabolic approach were provided. The latter involved either considerable filling and concrete work on top of the existing masonry arch that formed the floor of the turbine chamber, with the possibility of overloading the arch, or the expense and delay of a cast-iron casing. So it had been decided to accept the chances of eddy troubles and decreased efficiency and to place the turbine in the center of the original rectangular water chamber. Fig. 1 is a section of the mill, showing the arrangement of the turbine and draft tube.

When the installation was completed, the turbine was tested by throwing the generator on the system, and the manufacturer's warning promptly proved correct. The generator should have been able to carry 220 kw. at full gate opening, but when the load reached about 165 kw., corresponding to 75 per cent gate opening, the wattmeter readings would oscillate wildly for a few seconds, then drop suddenly to about 50 kw. or less,

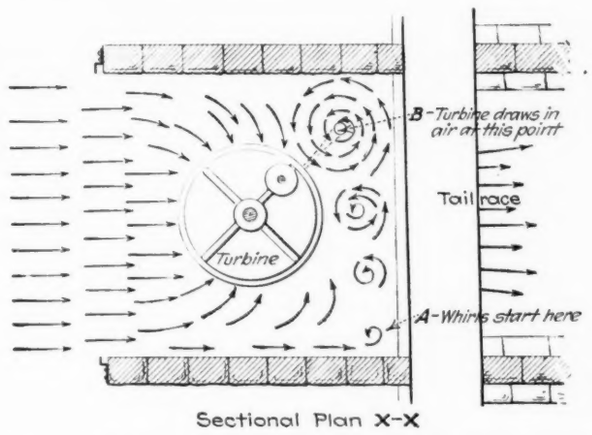


FIG. 2. PLAN OF TURBINE CHAMBER, SHOWING FORMATION OF THE EDDIES

The water starts whirling in the lower right-hand corner of the turbine chamber and travels across the rear of the chamber, growing in size until it lets air into the turbine.

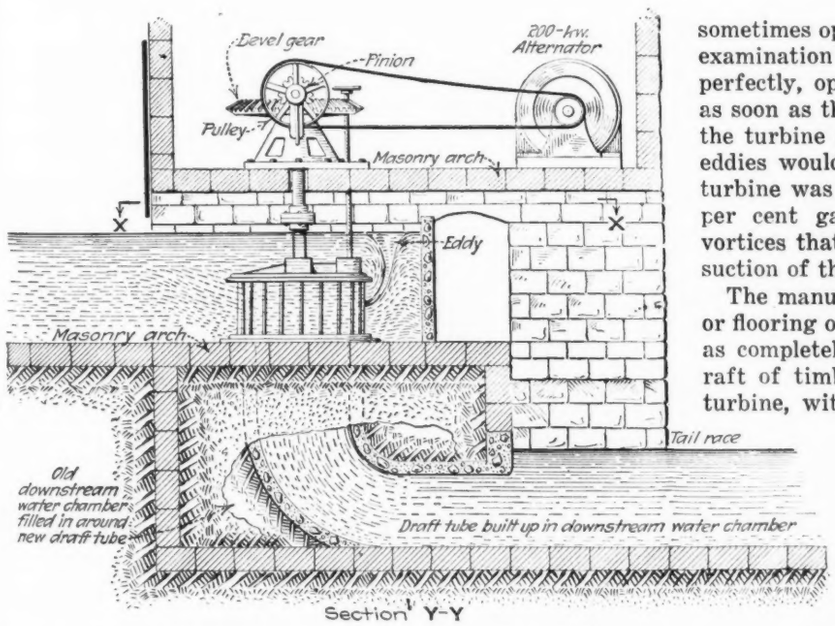


FIG. 1. CROSS-SECTION OF THE MILL, SHOWING THE INSTALLATION OF THE TURBINE TOO CLOSE TO THE SURFACE OF HEADWATER

Note the eddy drawing air into the turbine, thus breaking the draft tube's suction.

sometimes operating the reverse-current relays. An examination of the governor proved that it operated perfectly, opening up to the full gate immediately, as soon as the trouble started. An investigation in the turbine chamber proper disclosed the fact that eddies would begin to form almost as soon as the turbine was started, and that at approximately 75 per cent gate opening they developed into deep vortices that let air into the turbine and broke the suction of the draft tube, as shown in Fig. 1.

The manufacturer advised floating a wooden raft or flooring over the turbine, so as to shut out the air as completely as possible. So a heavy rectangular raft of timbers was built and assembled over the turbine, with two holes for the turbine and gate-operating shafts. The over-all dimensions were made slightly less than those of the turbine chamber, and substantial cast-iron rollers were mounted on the edges to roll on the walls of the chamber, allowing the raft to adjust itself to the changes in the upstream water level without danger of becoming jammed and lifted from the surface of the water. The arrangement of the raft is indicated in Fig. 3.

The results accomplished were disappointing. It was found possible to run the load on the turbine up to full-gate opening, but impossible to hold it more than about 1½ minutes. Air was still being drawn into the turbine around the edges of the raft, as shown in Fig. 3. Fur-

thermore, even though it had been possible to stop this by decreasing the clearances around the edges, this solution would not have been satisfactory, for the maximum load that could be reached at full gate proved to be about 185 kw., or 35 kw. below normal, owing to the excessive loss of head due to the eddies.

The writer then decided that a better solution would be to prevent the formation of the eddies rather than try to oppose their tendency to suck air. The timber raft was therefore removed. A brief study of the formation and movement of the whirls showed that the water started whirling in one of the rear corners of the turbine chamber (at *A*, Fig. 2) and that the eddy would then travel across the rear of the chamber (upward in Fig. 2), gaining in diameter and depth until at *B* it let air into the turbine. The first step in stopping the formation of the eddies was to prevent the moving water from penetrating into the rear corners of the chamber. This was accomplished by erecting wooden baffles, cutting off these corners from the rest of the chamber, as shown in the plan-section in Fig. 4. This, however, did not entirely eliminate the trouble, and there was still a marked tendency for whirls to form at the apex of the angle included between the baffles, mainly due, apparently, to the surface water that continued to travel toward the back of the chamber instead of turning down into the turbine. So a third baffle was placed as shown in the vertical section, Fig. 4, mounted in an oblique position on top of the side baffles, with the double object of turning the stream lines downward toward the turbine passages and of cutting off the seat of the whirls from the water surface, so as to oppose any tendency to draw air into the turbine.

The result of the last step was quite satisfactory. The turbine unit was able to carry continuously a load of 217 kw. at full gate opening showing a loss of only 1.36 per cent in the efficiency from that guaranteed by the manufacturer if a volute casing had been installed.

Curved baffles of suitable shape would undoubtedly have been more satisfactory, but would have cost many

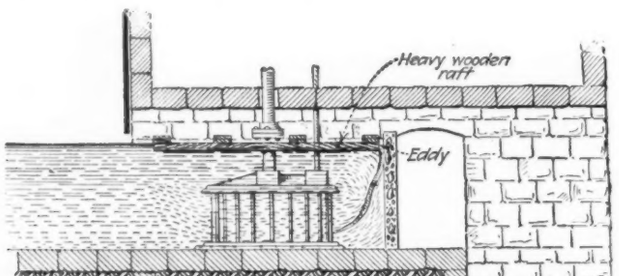


FIG. 3. CROSS-SECTION OF THE TURBINE CHAMBER, SHOWING FIRST ATTEMPT TO CORRECT TROUBLE

A timber raft was floated over the turbine to shut out the air.

times more—a rather severe disadvantage in view of the relatively short life that could be expected of the wooden structure.

No attempt was made to make the baffling watertight. On the contrary, the side baffles were built up of horizontal boards with clearances of ¼ to ½ in. between them, so as to allow the water level to remain approximately the same on both sides. The object was mainly to avoid undue strains on the structure, but also to avoid alternate wetting and drying of the wood which might shorten the life of the baffles, as the level varied on the inside. The top baffle had to be comparatively tight all over if it were to accomplish its object of stopping the indrawing of air; but a clearance of 1½ in.

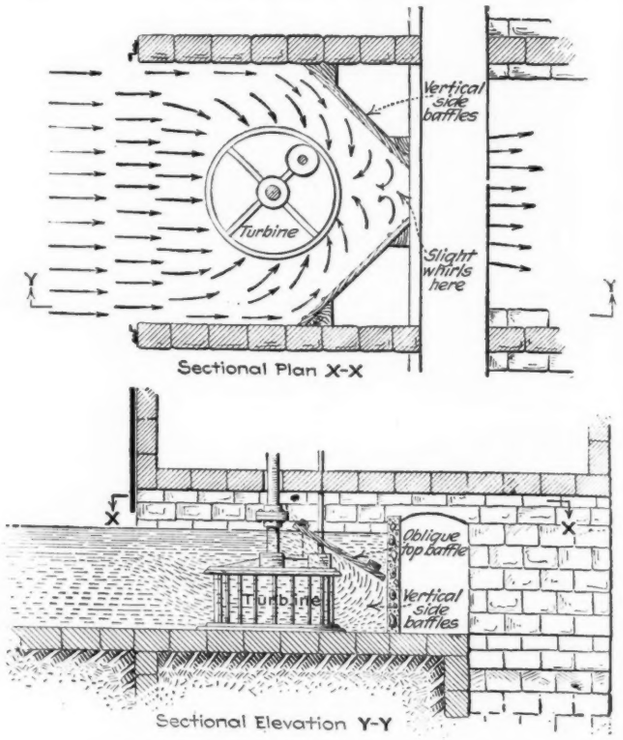


FIG. 4. PLAN AND CROSS-SECTION OF TURBINE CHAMBER, SHOWING METHOD OF CORRECTING TROUBLE

Baffles were installed to guide the water and to prevent the formation of the eddies.

was left all around the sides between it and the walls, to allow the water level to remain approximately constant on both sides.

Why Powdered Fuel Was Discontinued

Under date of July 5 *Power* described the installation of a powdered-coal system in connection with a return-tubular boiler at the Rialto Building, St. Louis, Mo., giving also the results of recent tests. Our attention has since been called to the fact that the equipment has now been removed, and we are advised by the chief engineer of the fuel company that the installation had been made largely for demonstration purposes; that the fuel was prepared at Terre Haute, Ind., and that it was too expensive to ship this to St. Louis; but that tentative plans are under way for the erection of a central preparation plant in the latter city to supply both large and small consumers.

This statement is supplemented by A. J. Dixon, author of the article, who, upon making later inquiry of the engineer of the Rialto Building, advises that the principal reason for removing the powdered-fuel equipment and restoring the original Hawley furnace was the uncertainty of fuel supply. There was also some difficulty due to leaky tubes, the method of firing apparently having an injurious effect on the tube ends, although Mr. Dixon was of the opinion that this should be chargeable to the boiler rather than to the furnace. —*Editor.*

Knocks in Diesel Engines

By LOUIS R. FORD

A DIESEL engine in normal operation and normally good condition produces certain characteristic noises, the resultant sound being a combination of those made by the air intakes to working cylinders and air compressors, exhaust gases passing at high velocity through the exhaust piping and the more metallic sound of the valve-operating gear. The engineer whose ear is attuned to the normal engine noises can quickly detect any abnormal noise, no matter how small in volume it may be, and is guided by its general character in his search for the location and cause of this noise. The most common indication of incorrect operating condition is knocking or pounding in the engine. There are three general classes of engine knocks, grouped according to whether they originate in the major bearings, in the valve gear or within the cylinders.

Worn Bearing Knocks

Bearing knocks are perhaps the most common in occurrence, owing to the constant and more or less rapid wear increasing the clearances in the bearings. Bearing knocks occur most frequently in the crankpin and crosshead-pin bearings for the reason that they are subjected to the most severe duty and consequently wear down most rapidly of all the engine bearings. Locating the particular bearing that is knocking by listening to the sound produced while the engine is running is more difficult in a Diesel engine than in a steam engine because the former is usually completely closed in and the areas of relative intensity of sound are not so clearly defined. In a multi-cylinder engine about the best that can be done is to locate the cylinder adjacent to which the knock occurs, then investigate when the engine is stopped, starting with crankpins and crosshead pins. A loud bearing knock that starts suddenly while the engine is running or a knock that increases in intensity very rapidly usually indicates a dangerous condition, such as a broken bolt or a loose nut, and the engine should be stopped at once for examination. If the bearing knock increases so slowly as to indicate that it is simply a case of gradual wear, the oil pressure in the lubricating system should be increased. This keeps the excessive clearance space in the affected bearing filled with oil, which acts as a cushion, deadens the noise and prevents pounding the babbitt out of the box. In small engines the loose bearing that is causing the knock may be located by working the connecting rod up and down with a heavy bar, but in large engines leads must be taken and the clearances measured. On engines that have been in service for a number of years the crankpins may become flat, causing a heavy pound. This cannot be eliminated save by truing the pin.

Knocks in Valve Gear

Knocks occurring in the valve-operating gear may be readily located on most engines, owing to the accessibility of this gear. This simply requires careful inspection of all parts and noting the sound. Some of the more common causes of knocks in the valve gear are: Too much clearance between cams and rollers, worn or broken rollers, badly worn fulcrum-pin bushings in valve levers, valve stems too tight or stuck in guides. In the case of inlet and exhaust valves that have a relatively high lift, examination of the valve will show whether or not it is coming back to its seat each time. If the valve cam knocks as it makes contact with the roller and the valve comes to its seat with a loud slam, the clearance between cam and roller is too great, but if the valve closure is comparatively quiet and the loud knock occurs at the cam, it is probable that the valve stem or guide is jammed so that the valve does not return to its seat after being pushed open. The lift of the spray valve is so small that its failure to seat firmly is not always apparent to the eye, but if the hand is placed on top of the valve stem a slight jar can be felt when the valve and seat make metal-to-metal contact. In this connection it should be noted that it is excellent practice to turn the spray valve stems a slight amount at frequent intervals while the engine is running, using a wrench on the squared upper ends of the stems. This is an aid to good seating of valves and prevents the wearing of grooves in the stem. In some engines a knock in the spray-valve operating gear is sometimes a warning that the spray-valve stem is binding in its guide, although the valve may still be coming back to its seat. In this case it is sometimes possible to free the stem by applying kerosene so that it will work down between stem and guide and cut away the gummy fuel oil that may have collected there. If the stuffing box is too tight the stem often binds.

Knocks Within the Cylinder

Knocks that occur within the cylinders have a characteristic sound that is easily recognizable by anyone who has heard them. A common cause of such knocks is excessive spray-air pressure. If knocking occurs in all cylinders it is probably due to this cause, but if it occurs in only one cylinder it is due to some cause that does not affect the engine as a whole. If the knocking takes place while operating at normal speed and load, the spray-air pressure should be slowly reduced until the knocking stops, then slowly raised until it is heard again. This will determine the air pressure with which it is permissible to operate. In engines not provided with means of adjusting spray-valve lift, it is not always possible to prevent this knock when the engine is operated at speeds below normal or when starting up. When the engine is started and before the pistons have acquired very much velocity, the expansion of gases in the combustion space occurs more rapidly than the increase of cylinder volume, so that sudden high pressures are built up in the cylinders, producing the effect of explosions.

Too much fuel fed into the cylinders produces knocking similar to the excess spray-air conditions. The same result will be produced by too rapid injection of the fuel. When persistent knocking occurs in one cylinder of a multi-cylinder engine, the fuel pump on that particular cylinder should be adjusted to feed less oil. If the fuel-pump adjustment is known to be correct, the knocking may be caused by broken atomizer discs or too few atomizer discs permitting the oil to be injected very rapidly. Intermittent knocking may be caused by a leaky spray valve that will deposit oil in the cylinder during the exhaust or suction stroke, causing preignition on the compression stroke.

Another common cause of cylinder knocks is incorrect timing of spray-valve opening. If the valves open too early, combustion of fuel will occur while the clearance volume is still decreasing and an abnormal pressure rise will result. This condition is most likely to occur following any overhaul work on the engine that involves disconnecting valves, valve levers, or camshaft, unless the timing has been carefully checked before the engine is started. It may also occur in some forms of engine construction while the engine is in operation by reason of the nuts that secure the valve levers to the valve stems becoming loosened and working up until the clearances between cams and cam rollers is reduced to zero. The timing may be affected by the adjustable cams or cam toes shifting while the engine is in operation, especially in that type of construction which provides screw adjustment for the cams, if care is not exercised in jamming the screws tightly. Knocking due to too early injection will sometimes result from a change in kind or quality of fuel. The spray valves may be timed right for a heavy fuel, but if no change in timing is made when a lighter fuel is turned into the engine, the light oil, passing through the spray valves more rapidly than the heavy oil, will cause too early combustion with resultant high pressures in the cylinders.

A kind of cylinder knock that is not so common and may at times be somewhat disconcerting results from an accumulation of gum or carbon in the piston-ring slots or jamming of rings due to the ring clearance in slots being too small. The rings may seize in their slots for a few seconds, then release and spring out to normal position against the liner. This action is intermittent, the duration of sticking being sometimes one stroke, sometimes several strokes. When it occurs, the gases in the cylinder will blow past the rings with a loud noise that sounds almost exactly like a heavy preignition knock or the piston striking the cylinder hard. If the sticking of rings is due to gummy oil in the ring slots, it may sometimes be relieved by injecting kerosene into the cylinders by means of the mechanical lubricators; if it is due to too little ring clearance in the slots, conditions may be improved by increasing the cooling-water supply to cylinders and pistons and reducing the working temperatures. In trunk-piston engines this noise will be considerably muffled because the open cylinder ends are inclosed within the housing. This may cause some difficulty in identifying the knock. In crosshead engines with cylinder heads outside of the housing the noise is much louder and is more easily identified.

Locking Device on a Turbo-Generator Fire-Extinguishing System

By W. G. Spencer

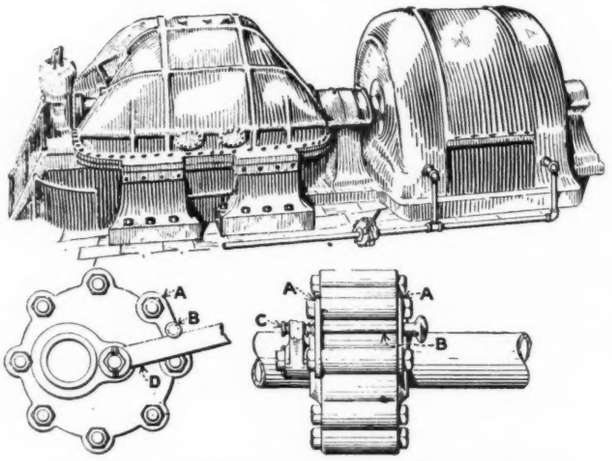
When the electrical end of a turbo-generator takes fire, it is difficult to extinguish. Steam or water is at present mostly employed in extinguishing turbo-generator fires, and the latter is largely favored because it can be applied directly to the seat of the trouble, the idea being to wet the windings as far as possible, whereas steam is largely depended upon to displace the air in the generator.

The usual method employed in applying water in case of a generator fire is by means of perforated pipe rings secured at each end of the generator inside of the end coils. The perforations are located so as to discharge a fine spray of water over the windings and air gap between the armature and the fields. The natural ventilation of the machine assists in spreading the water over the winding.

Any possibility of the accidental application of either water or steam to the generator winding must be guarded against. One method of removing any leakage past the valve that is between the source of pressure and the coils is to provide an open drip in the pipe near the valve.

There are several methods of protecting the valve from being opened by accident. One is to place two valves in series so that both must be opened before water can reach the generator windings. In this arrangement a drip is placed between the two valves.

In the illustration is shown an arrangement that is used on a large turbo-generator at the Pratt Street



LOCKING DEVICE ON QUICK-OPENING VALVE

station of the Baltimore Light and Power Co. The valve in the water-spray pipe is of the quick-opening-closing type. Secured by two of the bolts that hold the valve body together are two pieces of iron *A*, one on each side of the valve and drilled for the ½-in. pin *B*, which passes through the two pieces *A* across the outside surface of the valve body. On the end opposite the handle is a spring that holds the pin *A* in its extreme position to the left and is kept under slight compression by the collars *C*.

With the valve closed, the valve lever is in the position shown by *D* and the pin *B* extends past the lever, thus preventing the valve from being operated without first pulling the pin *B* to the right and against the spring. As it is only necessary to pull the pin to open the valve, no delay is occasioned by the locking device and an effective means is had for preventing the generator coils from being flooded by the accidental opening of the water valve.

The unemployment situation was surveyed by the Secretary of Labor recently upon the request of the Senate, with the result that the present total number of unemployed persons in the United States was put at 5,735,000. This was figured from the peak of employment in 1920, and is only an estimate, as exact figures are unobtainable. A considerable portion of this sum, of course, represents war workers who have returned to home or school work and are not, therefore, actually "unemployed."

Low Power Costs in a Small Flour Mill

BY FOREST E. JONES

In June, 1912, the Quality Flour Mills, of Austin, Tex., took out their steam plant and installed a Diesel engine to drive the mill, which has a normal capacity of 350 bbl. of flour per twenty-four hours. A 225-hp. American Diesel was installed and today stands as an engine of the "old school" still giving good service.

In spite of the fact that this mill has a low load factor, the power costs are much lower than in the average steam-driven mill, which can be attributed entirely to the Diesel engine. A summary of the cost for the six months from Nov., 1920, to April 30, 1921, follows:

	Lub. Oil, Gal.	Fuel, Gal.	Hours Run	Flour Made Bbl.
November	37.9	2,341	216	3,148
December	24.6	1,511	144	2,102
January	46.2	2,800	270	3,939
February	29.7	1,748	174	2,536
March	25.6	1,497	150	2,187
April	38.0	2,200	216	3,148
Total	202.0	12,097	1,170	17,060

Power Cost per Barrel of Flour

	Cents
Fuel	2.868
Lubricating oil and water	0.743
Repairs and supplies	2.620
Labor	7.925
Interest	3.162
Depreciation	3.915
Taxes and insurance	0.872
Total cost, cents per barrel of flour	22.105

The load factor for this period was 62.2 per cent considered on an operating basis of twelve hours a day. The mill manufactures corn products also, and the division of costs has been allotted as 90 per cent to flour and 10 per cent to meal and byproducts.

A test was recently run on the engine while driving the mill with normal load, and the results are of interest. The test was of short duration, and it was not feasible to take indicator cards on all cylinders at the same time. The friction load on the engine was calculated and taken as being constant for all loads. The fuel was measured by volume rather than by weight. In consideration of these facts some of the test readings may be considered inaccurate, but the average results obtained are thought to be not far from correct.

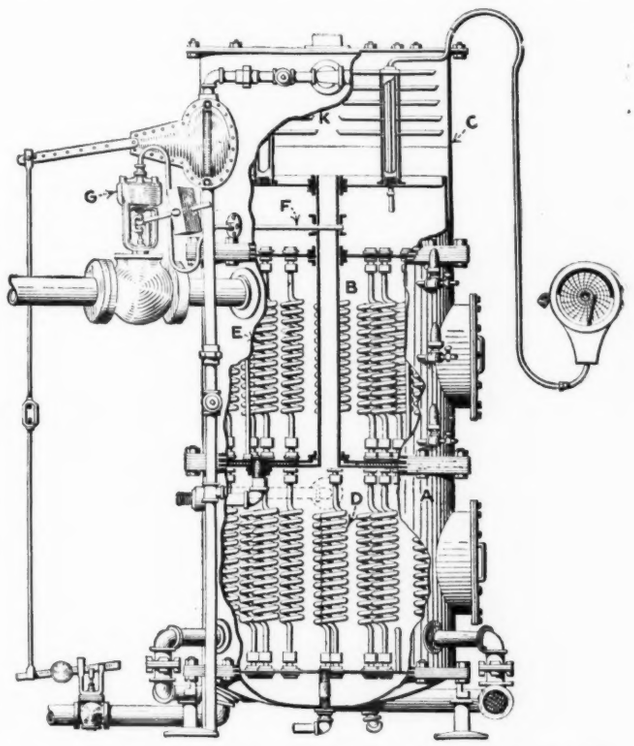
Fuel oil:	
Heating value, B.t.u. per lb	20,500
Flash point, deg. F	207
Gravity, deg. Bé. at 60 deg. F	33.3
Temperatures:	
Water inlet, deg. F	103.37
Water outlet, deg. F	123.23
Air inlet, deg. F	112.39
Exhaust, deg. F	935.39
Water, gal. per min	34.3
Fuel, lb. per B.hp.-hr	0.558
Mean effective pressure, lb. per sq.in	68.3
Revolutions per minute	163.3
Indicated horsepower	203.7
Brake horsepower	157.9
Mechanical efficiency, per cent	77.5
Thermal efficiency, per cent	22.3
Per cent rated load (load factor)	70.2

In testing an engine or a turbine for steam consumption by measuring the condensate, the engineer in charge is particular to see that none of the circulating water is drawn into the condenser and added to the condensate, thus increasing the apparent steam consumption. It is possible, however, for the reverse condition to exist when there is a long discharge main in the circulating system sealed at its point of delivery. Under these circumstances there may be a better vacuum in the circulating system than there is in the condenser itself, so that, in case of leakage, water would pass outward from the condenser and the apparent steam consumption of the engine or turbine would be reduced.

Deactivator Deaerating Apparatus

Rusting of water pipes, especially of hot-water pipes, falls to the lot of most engineers. Hot-water pipes give the most trouble, because the formation of rust is assisted by the application of heat to the water. Three elements must combine to form rust—water, iron and air. If the oxygen in the water could be eliminated, the rust problem would be solved.

A deaërating apparatus for preventing pipe corrosion, known as a deactivator, and manufactured by the Anti-Corrosion Engineering Co., Inc., 117 West 54th St., New York City, is designed for the purpose of preventing



APPARATUS FOR REMOVING AIR FROM HOT WATER

rust in water pipes. The deactivator is constructed with an exchange *A*, booster heater *B*, using a low-pressure steam, and a deaërator *C*. The two lower sections *A* and *B* are porcelain lined, and the coils, pipes, pans, diaphragm, etc., are of copper or are of tobin bronze.

Water that would normally pass directly to the feed-water heater is passed through the deactivator, first going through the coils *D*, in which it is heated by the exchange of heat from the hot water that is leaving the deactivator. The incoming water also passes through the upper coils *E*, in which the water is raised to 207 deg., the temperature being regulated by the thermostat *F* and the steam valve *G*. At this temperature the water gives up its dissolved gases as it falls over the cascade plates *K*.

The treated water is taken from the bottom of the apparatus or the exchanger section, in which it gives up a large part of its heat to the incoming cold feed water.

Tell me what a man does when he has nothing to do and I will tell you what manner of a man he is.

"Combusco" Ash Conveyor

An improved type of ash conveyor, known as "Combusco," consists of a scrape or drag link conveyor, working in a trough containing water, and situated beneath the part of the furnace where the ashes are dumped. The hot ashes and clinkers are quenched as

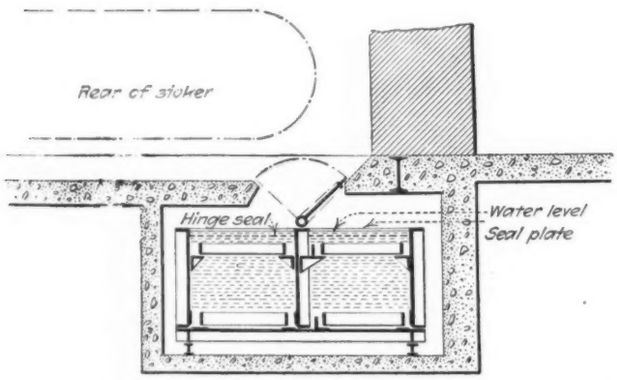


FIG. 1. DOUBLE CONVEYORS IN SEPARATE TROUGHS

they fall and as the clinkers break up upon reaching the water, their handling is facilitated.

Fig. 1 illustrates the standard method of installing, where two conveyors are placed in separate troughs with a hinged door between them for diverting the flow of ashes into either one or the other conveyors. The trough is usually built of ribbed cast-iron plates that extend the length of the boiler house, and is about two feet high. In the design shown, the ashes and clinkers pass through the return chain into the lower

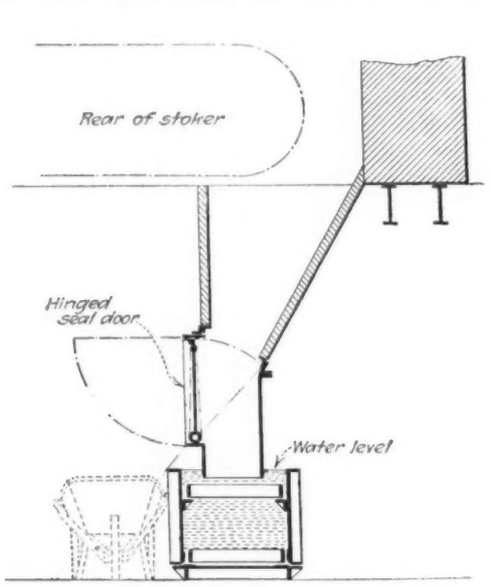


FIG. 2. CONVEYOR DESIGNED FOR SMALL PLANT

operating part of the chain, there being sufficient space between the chains and scrapers. A small conveyor may be installed in small plants, as shown in Fig. 2, when a duplex system would not be warranted.

As the design utilizes the existing ash tunnel and provides for emergencies, an alternate outlet on the chute is used so that the ashes may be discharged on the floor of the tunnel to be removed by other means. The ash chute allows the clinkers to drop from the furnace into the trough, the discharge end of which is about 18 in. wide by 3 ft. along the trough, permitting the largest clinker to pass readily.

The sides and bottom of the trough are interchangeable. The steel scrapers are ¼ in. thick, 4 in. high and 18 in. long; the chain is of drop-forged steel. Air leakage from the sides of the ashpits is prevented by sheet-steel seal plates that extend into the water in the trough. The water level is maintained approximately constant by a float valve that controls the make-up water.

At the delivery end the chain may be continued horizontally, or on an incline to discharge into cars, or into a bunker or otherwise disposed of. Fig. 3 shows inclined troughing in which idle sprockets are introduced at the change from the horizontal to the inclined run. The sprockets at the end of the incline

FIG. 3. CONVEYOR WITH INCLINED DISCHARGE

are connected by means of reduction gears to a motor or engine drive so that the maximum travel of the conveyor will be 17 ft. per minute, at which speed it is estimated that about ¾ hp. will be required for 1,000 lb. of refuse handled per hour, the capacity of the conveyor being about 2½ tons per hour.

This conveyor is being manufactured in this country by the International Combustion Engineering Corporation, New York City.

The watchfulness necessary with the larger apparatus now used in power stations is made apparent by the following. In a certain station is a bearing, and it is not exceptional, which supports a weight of 11 tons revolving with a surface speed of 8,250 ft. per min. or 137.5 ft. per sec. Taking the coefficient of friction as 0.0025, the mechanical equivalent of the heat unit as 778 ft. lb., there would be developed each second in this bearing

$$\frac{11 \times 2{,}000 \times 0.0025 \times 8{,}250}{778 \times 60} = 9.7 \text{ B.t.u. per sec. or}$$

more than heat enough to raise the temperature of 70 gallons of water one degree each minute.

Great Britain imported 3,368,600 tons of oil in 1920, while the annual production in the United Kingdom (Great Britain and Ireland) is about 170,000 tons. Of the 1920 imports, 61 per cent in quantity and 68 per cent in value came from the United States and but 2 per cent in quantity and value from British possessions, the remainder coming from other countries.

EDITORIALS

Turbo-Generator Cooling

COOLING air for dissipating the losses in turbo-generators has always constituted somewhat of a problem. Such large quantities of air are involved that the difficulties of handling, transmitting and cleaning are considerable. The amount of air required varies from four cubic feet per minute per kilowatt of capacity down to about two and one-half cubic feet for the larger units.

Cleaning this air so that foreign matter will be kept out of the generator, where it would lower heat transfer by coating the insulation and interfere still further with heat dissipation by clogging up the ventilating ducts and so reducing the flow of air, is a matter of paramount importance. Of hardly less importance, though less pressing because less conspicuous in its need, is that of preventing air from reaching the generator windings in case of fire. It often happens that in eliminating one fault other objections are overcome incidentally. By solving the air-washing problem, a number of other problems are also solved.

Instead of continually drawing fresh air from the atmosphere, washing and cooling it, passing it through the generator and then exhausting it to the atmosphere, or in isolated cases to the furnace, there is a marked tendency toward a "closed" system by which the same air is used over and over again with the addition from time to time of makeup air to replace that lost by leakage.

When one or more tons of air must be cleaned per minute, cleanliness becomes a relative term. Air once cleaned thoroughly and recirculated remains clean. A typical instance will make this clearer. A twenty-five-thousand-kilowatt turbo-generator using the open system of ventilation where the cooling air is used only once, requires about two and one-half tons of air per minute. The same machine using the closed system, where the same air is recirculated many times, requires about one hundred and fifty pounds of air, which is circulated and cooled about thirty times a minute. With so small a quantity of air used almost indefinitely, air washing and cleaning no longer constitute major problems.

Coincident with the elimination of large quantities of air for cooling passes also the chief factor in the fire hazard—namely, an ample supply of oxygen for combustion. Since combustion cannot be supported without oxygen and since the closed system does not provide sufficient oxygen for active combustion, it seems that a long step has been made toward abating the fire hazards of turbo-generators. The use of steam or water connections in the generator casing (the majority of the companies favor the latter) as a ready method of quenching a fire remain, doubtless, good expedients; but it would seem that there should no longer be any need for suggesting inert gases such as carbon, tetrachloride, carbon dioxide, etc. With the closed system means should be available, however, for taking in outside air should the spraying or cooling system fail, a precaution that presents no more difficulties than does the present open system.

The recirculation of air appears to be especially worth while where the air is highly contaminated and cooling water plentiful, just as the surface condenser is usually indicated where condensate has a use and cooling water is suitable and plentiful. The logical location for the air-cooling apparatus is the foundation of the generator, just as the foundation of the turbine is the logical location for the surface condenser. The one cools air, the other steam; both cool a gas, and both use water as the cooling medium. The unity of purpose, the proximity of location and the use of identical cooling media suggest that perhaps an opportunity may exist for some interesting developments in the way of design and in the recovery of generator heat losses for the heating of condensate. There may be further economy in that during seasons when considerable margin between hot-well and cooling-water temperatures exists, the amount of water used for condensing may be reduced by using some of the water for both condenser and air cooler.

Regardless of incidental advantages, the closed ventilating system reduces the air-cleaning problem, it abates to a great extent the fire hazard, it tends to simplify station layout and enables a generator to remain longer in service without being taken out for cleaning.

From Conjecture to Certainty

REAL progress in any field of endeavor is made only after one begins to have an understanding of what is being dealt with. After Watt developed the steam-engine indicator, thus providing a means of knowing what was going on inside the cylinder during operation, improvement in engine design was given an added impetus. Many factors influenced this progress, but undoubtedly providing a means for analyzing the performance of the engine was the predominating one. In the economic operation of the engine plant the indicator became the most important device at the engineer's command for maintaining efficiency.

Knowing something about what was going on in the middle of the process without some knowledge of what was happening at each end was not very enlightening. With a pressure gage only on the boilers and a belt from the engine flywheel to a lineshaft in the engine room, little opportunity was afforded to analyze plant operation. About the best that could be done was to keep the boilers clean, eliminate steam leaks in valves and piping, keep the engine valves tight and properly adjusted and the shafting in alignment. The actual results obtained from this procedure were more rough estimates than anything else, therefore not conducive to creating an interest.

The introduction of electrical transmission of power marked the transition from what may be called the dark ages in power-plant operation to that of understanding. Until this time no convenient means was available for

determining the amount of power produced. With the electrical generator substituted for the main belt and lineshaft, it was possible, with nothing more than a voltmeter and an ammeter, to determine the load on the plant at any time. With the development of the recording and integrating types of wattmeters permanent records of the load on the plant were obtained.

Knowing the total weight of coal burned during a given period and the kilowatt-hours output made it possible to determine conveniently how much fuel had to be burned to produce a unit of power, and therefore to what extent different elements in operation affected the economy. To be able to do this was a step forward in power-plant operation. There are, however, a great many steps between the coal pile and the switchboard that require definite knowledge at all times in order to obtain the highest economy. Within the last fifteen years numerous devices have been developed to give this information so that in the modern station a meter board is placed at each boiler to show the conditions in the boiler and furnace at all times. With this information the attendant knows what adjustments are necessary to keep each boiler operating at its highest economy for given load conditions. At the turbine there is also a meter board showing the conditions under which that part of the plant is operating. In other parts of the plant are found meters for recording the flow of steam, water, recording temperatures, etc., so that the modern power plant might be considered to be running under test conditions and its operation is accordingly changed from a matter of conjecture to one of certainty.

Superpower for France

IT IS ALWAYS interesting to note the metamorphosis of an idea after successive stages of incubation in different minds. An interesting example of this phenomenon is to be found abstracted on page 342 of this issue. The seed sown by Mr. Murray has blossomed in the minds of two French engineers, and borne a fruit of surprising form. The most remarkable point of this plan for superpower development in France is that the energy is to be transmitted over great distances, but apparently there is to be no interconnection at the receiver end of the line. The reasons for this unexpected proposal are twofold. First, to avoid the problems of voltage control in a network, which are considered impossible of solution; secondly, to better safeguard the autonomy and individual rights of the distributing companies. The writers of the article seem serenely unconscious of the fact that vast transmission networks have been in satisfactory operation in this country for many years, and that the synchronous condenser, together with suitable regulators, have brought voltage and power-factor control in a network well within the tolerances of practical operation. Therefore, in order to sidestep troubles that have already been overcome, three of the prime advantages of superpower that are dependent on interconnection are thrown to the winds—higher load factor, better diversity factor and greater reliability of service. As to the safeguarding of the interests of the different distributing companies, it can certainly be best accomplished by providing them with continuity of service.

These are not the only surprises afforded the American engineer in the proposed project. In order to increase the load factor of the steam plants, it is proposed to store off-peak energy by using the electrical energy generated during off-peak hours, to heat up feed water for use during the peaks. A few figures might be enlightening on this point. A one-hundred-thousand-kilowatt plant with a full-load peak lasting six hours a day would require the storage and preheating of about one hundred and twenty thousand cubic feet of feed water during the eighteen off-peak hours. This would require a hotwell thirty feet deep and seventy feet in diameter. The insulation of such a tank to prevent heat losses through the walls would constitute quite a problem.

Moreover, there is a limit to the amount of power that could be absorbed in this way. Assuming extreme conditions, where the condensate from the main units is chilled by the makeup water to about sixty degrees Fahrenheit, and it is desired to heat it up to two hundred and ten degrees, an average of twenty thousand kilowatts could be so utilized during the off-peak hours. This would undoubtedly give an appreciable increase in the load factor, but it is doubtful whether any saving could be effected in this way. Granting that elaborate computations could justify this consumption of coal for no other purpose than heating feed water for the peaks, there is no doubt that this could be done more economically by turning the high-pressure steam from the boiler directly into the hotwell, thus saving at least the amount of the turbine and generator losses. When all is said and done, there is little doubt that the finest computation would be upset by the heat loss from the hotwell.

Progress in Boiler Inspection

GOOD news has recently come from Ohio (detailed on another page) that the Board of Boiler Rules in that state has put the weight of its authority behind the National Board of Boiler and Pressure Vessel Inspectors by agreeing to accept boilers inspected outside of the state under the by-laws of the National Board.

This is the only way in which the National Board can be given authority; that is, by the voluntary agreement of its members to accept its inspection service. Only when every political subdivision represented in the Board's membership has taken similar action will it be in a position to render the full service planned for it. It is to be hoped that other states will follow the example set by Ohio and make these plans a reality.

The very fact of the slowness with which the Board has developed indicates, in a way, the honesty of its purpose. Plans that spring from a selfish or mercenary source are generally enthusiastically sanctioned and quickly brought to a head, while those of a co-operative and public-spirited nature are somewhat harder to get under way. It is to be regretted, perhaps, that more enthusiasm has not been shown by the members of the Board in its formation. On the other hand, the difficulties to be met have been great. Political jealousies, the great distance existing between members, the apathy that invariably greets a new proposal of any kind—these have made it practically impossible to secure speedy action.

At any rate, progress is being made, and in the right direction. It will be a matter of interest to note what state will be the next to help the Board to become really useful and to function as was intended when it was organized.

CORRESPONDENCE

Repaired Exhaust Valve Made Saving

The exhaust from the head end of a 60-year-old 22 x 48-in. engine, at 35 r.p.m., was heavy, but light from the crank end, and as the cutoff was equal this condition indicated a bad leak of the exhaust valve on the head end. Indicator diagrams were taken and the crank end showed very good conditions. Fig. 1 shows the diagram secured from the head end. The rapid fall of the expansion line indicates a leaking exhaust valve, and the absence of compression indicates that it may leak during the entire stroke.

The exhaust valves of this engine are driven by gears from the crankshaft. The driven gear was moved forward one cog, thus advancing the movement of the exhaust valves to that extent. Fig. 2 is the next diagram taken, and the slight compression secured shows that the exhaust valve did not leak at the beginning of the stroke. The driven gear was moved forward another cog, and Fig. 3 shows the result. It presents evidence that the exhaust valve leaked badly at about one-half stroke.

FIG. 1. HEAD-END DIAGRAM

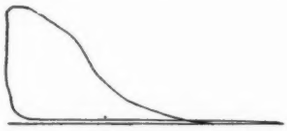


FIG. 2. SECOND DIAGRAM TAKEN

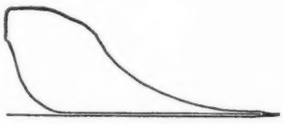


FIG. 3. THE THIRD DIAGRAM

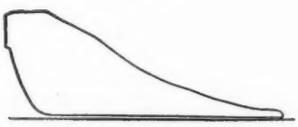


FIG. 4. SHOWING TIGHT VALVE

The crank was put on the inside center, the cylinder head removed, and the clearance filled with hot water. It leaked out past the exhaust valve, but at a very slow rate. The crosshead was advanced to one-quarter stroke, and the clearance again filled with hot water. It disappeared much faster than before. The crosshead was advanced to one-half stroke, and the clearance again filled with hot water. It ran out rapidly, showing that the leak was greatest at this point, agreeing with the readings of the indicator diagram.

It was necessary to remove the cylinder from the frame in order to take out the exhaust valve with its removable seat. Both were planed off and entirely refitted. All parts were replaced and another diagram taken, which is illustrated in Fig. 4. It shows that the valve is tight and the puffs of exhaust steam are now of equal size.

Tests made before and after the repairs show that a saving of 900 pounds of coal a day resulted, which is 18 per cent of the weight formerly burned.

A still further saving was made as follows: The fuel burned was a mixture of four parts anthracite dust to one part of bituminous coal, the latter costing three times as much as the former. After the repairs the less amount of steam required enabled the engineer to use six parts of dust to one part of soft coal, reducing the cost per ton 10 per cent. The net saving is about $3 a day in the fuel bill, and the cost of repairs was about $200.

W. H. WAKEMAN.

New Haven, Conn.

This Belt Ran to the Low Side

I have noted the many discussions on belts and why they run up, and I have also read with particular interest the editor's digest at the foot of Mr. Christopher's article in the June 19 issue of *Power*, concerning the disagreement as to the way belts run on straight pulleys.

We have a horizontal waterwheel with a pulley 8 ft. in diameter, having a 24-in. crowned face. By means of a 16-in., 3-ply leather belt running slack, this drives a horizontal, two-bearing generator, with paper pulley of 18 in. diameter and 18 in. face.

The belt was noticed to be running up on the generator bearing. When this had happened before, the operator had shaved down the high side of the paper pulley and thereby brought the belt back to center. However, this time this remedy had no effect. Upon close observation the side of the belt nearer the generator appeared to have considerably more slack than the other side. The generator was taken off of the line, but still allowed to turn over slowly. It was then twisted slightly on its bedplate, so that the outside edge of the pulley was brought nearer the waterwheel and the other side moved farther away. In other words, the generator shaft was lined into parallelism with that of the waterwheel using the slack in the belt as a guide, since this caused the belt to incline to horizontal. When the belt was perfectly level, the machine was tightened down and put back on the line. The belt ran perfectly true, thus substantiating the statement that on straight pulleys the belt does not run off the high side.

Fredericksburg, Va. J. B. SICKLEN.

Central Stations Versus Heating Plants for the Generation of Power

An article in the July 26, 1921, issue by Ira N. Evans calls attention to the fact that there is a large movement under way for superpower systems, but that no consideration is being given to the heating problem. This article goes on to explain how electric energy may be generated from properly designed heating plants as a byproduct. The idea of using the exhaust from an engine, and in later years a turbine for heating, has been much discussed and often tried. Central stations have been built and operated for exhaust heating. There are many in use today, and I believe that in the majority of cases the central heating station has failed to stir up any great amount of enthusiasm by the profits it has made. Theoretically, there seems to be a lot in the case in favor of the exhaust-steam heating idea. Not so long ago a prominent man indicted American engineers and power-plant operators as wasters because they threw away 80 per cent or so of their coal in heating up the rivers and lakes of the country by condenser circulating water. It is, indeed, unfortunate, at least from the power-generating viewpoint, that the latent heat of vaporization of water is such a large figure. However, we can not change it and so must make the best of it. Perhaps some day the mercury boiler or some such scheme will in effect reduce this figure.

In the case at hand, if I have understood the article correctly, it is claimed that the efficiency of heating plants will be lower if they are only allowed to do heating. Now, I believe this point is given unnecessary stress. The efficiency of a heating plant depends a good deal upon design and workmanship. If the plant is carefully built, with good equipment and furnaces of generous proportions, there should be little difficulty in getting satisfactory results. It is true that the operators must have some experience and be able to keep the plant in good repair. It is generally agreed that a satisfactory heating plant will recover 60 per cent or more of the available heat in coal. I would estimate that the combination heating and generating plant proposed by Mr. Evans would have an efficiency not to exceed 66 per cent. This is not a very large economic gain, and the great advantage of the combination plant must be sought in some other field. Now, the electric load that would be available for average combination heating plants would have a very poor load factor. Connecting such plants into a central-station system might help the combination heating plant, but would be of doubtful value to central stations. It is true that a small quantity of coal could be saved to the community, but there would be increased cost of operation and investment that would probably more than offset the fuel saving.

We are all looking forward to the time when our cities will be cleaner and when the air will be nearly as good as that in the open country. This is to come about by electrification. Already great strides have been made by the electrification of railroad terminals and of large as well as small factories. It is a far cry to electric heating, but some progress has been made even in that direction. Electric heating is now in successful commercial use for baking food, drying paint, in foundries for core baking, in steel mills for furnace work, in the melting of brass, type metal, silver and other soft metals, and to a limited extent for the heating of rooms in moderate weather, as well as quite largely for domestic cooking. It will be a long time, however, before we will want to pay the price of heating our stores, offices, etc., by electric heat. Until that time, we will go on using coal, oil, gas and wood.

In the matter of transportation alone the hauling of coal and ash is a burden everyone would be glad to get rid of. It is argued that the same quantity of coal would produce additional electric energy. However, if the combination plant is to approach a paying basis, it must be operated on a higher load factor than the plain heating plant. It must burn more coal annually, and it would have to operate four or five months in the warm season when the heating plant could be shut down.

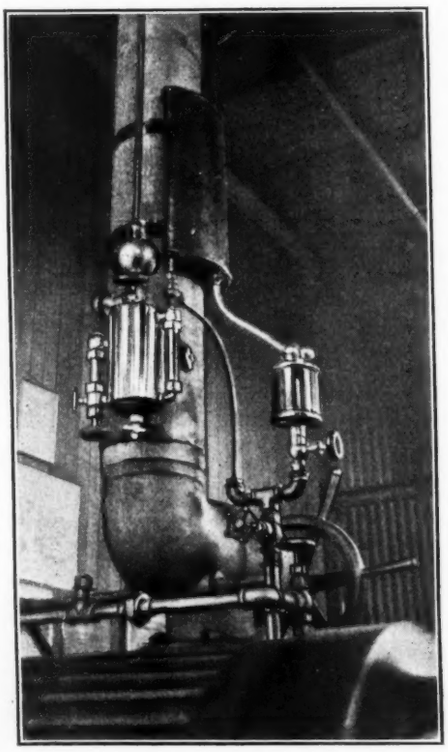
There is a justification for burning oil or natural gas for heating, but there would be no justification for using either for a generating station. Now the alternative of building large central heating plants has been tried and does not work out—the investment is too heavy.

LOUIS R. LEE.

Columbus, Ohio.

Filling Tank for Hand Pump

B. E. Eckard's lubricator arrangement on page 861 of the May 24 issue is the same as I installed when the idea first appeared in *Power*. This arrangement works well, but I went a step farther and added a tank from which to fill the hand pump by gravity.



OIL TANK SECURED TO STEAM PIPE

In the illustration a tank is shown secured to the steam pipe. It is made of tin, concaved on the side next to the steam pipe and is attached by a pair of tin bands, which are soldered to the tank and clamped about the pipe with stove bolts.

In the bottom of this tank is soldered a pit cock to which is attached a short piece of brass tubing running to the small-filling funnel on top of the hand pump.

I found it rather an awkward job pouring oil out of a pot into the top of the hand pump, and this added kink did away with that. Now I have a large reservoir of hot oil that can be run into the hand-pump at any speed, and I can fill and pump at the same time. The tank holds about one gallon.

R. MANLEY ORR.

Vancouver, B. C.

Precautions to Be Observed in Testing Generators for Grounds

In reference to L. R. Gray's article on page 774 of the May 17 issue, describing the testing for grounds on a damaged generator, it may be possible that the accuracy of the test was somewhat impaired owing to the voltage drop across the water rheostat. That is, assuming that the voltage was read on the 220-volt supply, there might be an appreciable voltage drop across the water rheostat due to the exciting current, even when the electrodes of the rheostat are brought together, owing to corrosion of the plates that nearly always takes place when a rheostat has been in use for any length of time. This might give a reduced voltage at the transformers, so that 4,600 volts was not actually being obtained on the high-voltage side. A water rheostat should always be equipped with a short-circuiting switch, as this is the only way of obtaining a positive contact.

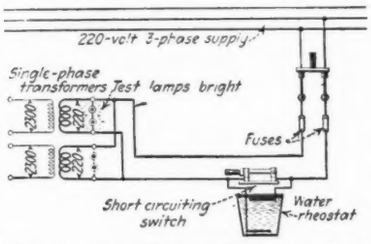


FIG. 1. TESTING PRIMARY VOLTAGE WITH LAMPS

If the lamps burn brightly, the transformers are under full primary voltage.

In such a test the important point is to be sure that the full high-tension voltage is being impressed on the windings. In connecting transformers in series or multiple, even with only two coils, there is always a possibility of getting the leads reversed, so that the coils oppose instead of assisting each other, and it is always best to read the voltages at the transformer terminals, preferably on the high-voltage side if possible. This requires a potential transformer, which may not be available. In this case the only way to be sure that the transformers are correctly connected is to test out the circuit carefully.

A convenient way of making this test, using only 110-volt 25- or 40-watt incandescent lamps, is as follows:

The first step is to determine that 220 volts is actually being impressed on the transformer primaries. With the water rheostat short-circuited and the secondaries open-circuited, connect two lamps in series across the primary terminals of the two transformers in turn, as shown in Fig. 1. If the lamps light up with normal brilliancy, the transformers are under full primary voltage.

The next step is to determine whether the secondaries are connected in series or in opposition. With the main switch open, the transformer secondaries still open-circuited, and the water rheostat short-circuited, connect two lamps in parallel with each other and in series with the transformer primaries and the rheostat, as shown in Fig. 2 A. Then close the main switch for an instant only to be sure that the lamps are not under too high a voltage. For best effect they should burn somewhat dimly. If they are too bright, it will show that their combined resistance is too high to allow sufficient drop across the transformer terminals, and more lamps should be added in parallel, as shown in dotted lines, until they all burn dimly. If the transformers are of very small capacity, the lamps may not light up at all, but this will answer the purpose all the same. Now connect up the secondaries, and test as follows, to see if they are in series or in opposition. Open the main switch and short-circuit the open leads of the secondaries, as shown in Fig. 2 B and C. Then close the main switch. If the lamps remain dim, the transformers are opposing each other, as in Fig. 2 B, and the secondary leads of one transformer should be reversed. If they light up with more than normal brilliancy, the transformer secondaries are in series, and connected to supply the full 4,600 volts between outside wires, as in Fig. 2 C. The ground test described by Mr. Gray may now be undertaken with the certainty that 4,600 volts are being applied to the windings.

The explanation of the foregoing is as follows: When the secondaries are open as in Fig. 2 A, the two primaries act as high impedances, and the drop across them reduces the net voltage across the lamps; for the geometric sum of the drops across the transformer primaries and across the lamps must remain equal to 220 volts; this makes the lamps burn dimly. If the connections of one secondary are reversed, as in Fig. 2 B, there is no voltage between the outside wires and no current will flow in the secondaries when these leads are connected together. Therefore, there will be no change in the primary circuit and the lamps will remain dim. If the secondaries are correctly connected, as in Fig. 2 C, there will be 4,600 volts between outside wires, and a certain current will flow when these are connected together. This current will demagnetize the cores of the transformers and so reduce the reactance of the primaries to a considerable extent. The drop across the primaries will therefore be reduced,

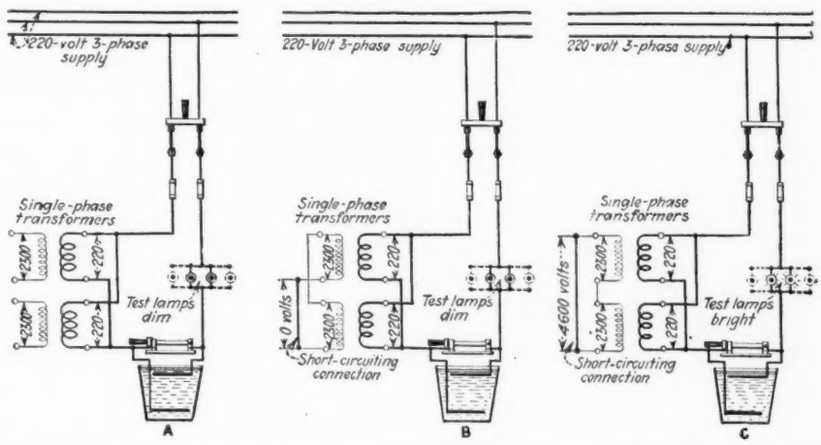


FIG. 2. TESTING SECONDARY CONNECTIONS WITH LAMPS, TO DETERMINE IF THE SECONDARIES ARE IN SERIES OR IN OPPOSITION

A—Preliminary adjustment: With the transformer secondaries open-circuited connect enough lamps in parallel, as shown, to make them burn dimly. *B* and *C*—With the main switch open connect up the secondaries. If the connections are correct, as in *C*, the secondaries will produce 4,600 volts between the two open leads. If they are wrong, the secondaries will produce zero volts between the open leads, as in *B*. To determine which of the two connections has been made, with the main switch still open, short-circuit the open leads as shown in *B* and *C*, then close the main switch for an instant. If the lamps remain dim, the secondaries are connected in opposition and the connections on one of them should be reversed. If the lamps burn up with more than normal brilliancy, the secondaries are connected in series, and 4,600 volts is being obtained between the open leads.

and that across the lamps will be increased, causing the latter to burn more brightly.

It would have been satisfactory, also, to have connected the water rheostat in the secondary circuit, between the transformers and the ground, so as to insure 220 volts being applied to the transformer primaries. There would have been no appreciable drop of voltage across the rheostat even though the electrodes were not brought together, as no current would flow until the ground caused an arc over, and the rush of current would have been prevented when the arc occurred by the resistance of the water. Very little salt should be used, and care should be taken to have the rheostat connected in the grounded lead. No adjustment to the rheostat should be made while the power is on.

Milwaukee, Wis. HOWARD D. MATTHEWS.

Boiler-Room Gages

Instruments necessary to check the operation of the small turbine plant are usually bought. Vacuum and pressure gages, temperature recorders, bearings thermometers, etc., are secured as a matter of course and are deemed necessary for operation. There are, however, any number of small plants where the only instruments in the boiler room are the steam-pressure gages on the boilers.

A master steam gage showing the steam pressure in the main header is valuable and should be placed in the

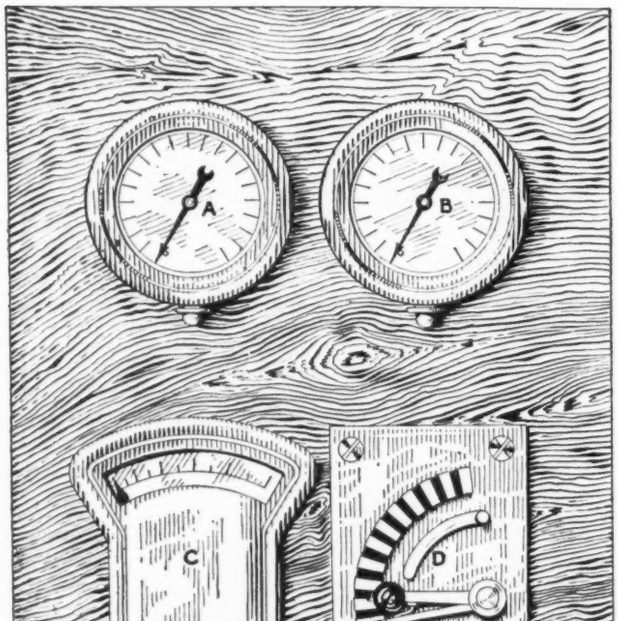


FIG. 1. PRESSURE GAGES AND LOAD INDICATOR

boiler room in plain view of the firemen. Sometimes the money to purchase a large illuminated gage, graduated in one-pound divisions, cannot be obtained. Many plants, however, have a spare ordinary steam gage that can be rigged up for use as a master gage to enable the boiler-room men to maintain a uniform steam pressure.

Gages showing the pressure of the feed water entering the boiler, and also that of the feed water entering the heater, are valuable in informing the watertender as to how his pumps are operating. By a glance at these gages, which should be mounted on a board in a central place in the boiler room, he can tell whether his pumps are performing smoothly.

The gages shown in Fig. 1 were mounted on the wall in the boiler room of a plant where considerable water trouble was experienced. Gage *A* showed the pressure

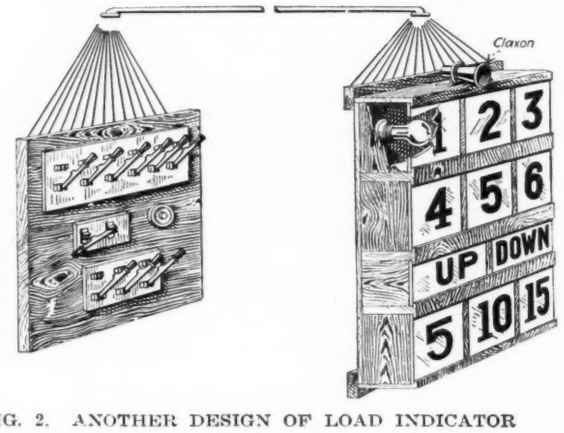


FIG. 2. ANOTHER DESIGN OF LOAD INDICATOR

of the water entering the feed-water heater and *B* showed the pressure of the feed water entering the boilers. The pumps in this case were in the rear of the boilers. Before the installation of the gages it was necessary for the watertenders to make a trip every few minutes to see that the pumps were operating smoothly. Rearrangement of the pumps relative to the water supply has since alleviated this trouble. The gages, however, are still in use and are an aid to the watertenders.

The instrument *C* on the board is a small ammeter graduated in kilowatts and used in connection with a small rheostat *D* controlled by the operator. The load on the boiler room is thus kept continually in view of the boiler-room foreman, and knowing the load for which he is supplying steam, he can oftentimes secure better efficiency from his boilers.

The load indicator shown in Fig. 2 was installed in the boiler room of a plant the principal load of which was a large steel mill. The load was a very fluctuating one and varied considerably. Arrangements were made with the mill so that the plant was advised at what time the various blooming, bar and sheet mills would come on and when they would go off. This information was telephoned to the switchboard operator, who in turn communicated the changes in the kilowatt load to the boiler room. It was not possible in this case to install telephone communication between the boiler room and the switchboard. By use of this board, which had a lamp behind each panel, the boiler room was advised of coming changes in the load and the interval of time in which they could occur. This particular plant had ten 5,000-sq.ft. hand-fired boilers serving a 10,000-kw. load and has been enabled to carry this load with a fairly uniform pressure.

All the instruments described were secured and installed at small cost. The load indicator was built in the plant. Their value has beyond a doubt justified their installation. To secure efficient and steady operation of the boiler room, install the necessary instruments so that the men may know the conditions under which they operate. S. R. FINLEY.

Masillon, Ohio.

Boilermakers as Inspectors

M. P. Johnson's criticism, on page 192 of the Aug. 2 issue of *Power*, of my previous brief remarks concerning boilermakers as inspectors is well taken on several points. However, it would have been unnecessary had I been writing on that subject primarily, instead of criticising remarks of Mr. Palmer's boiler joint calculation.

In the first place let me dispel all doubt by saying that I speak from the standpoint of one who has been engaged in all three lines of work in question and has hired, trained and supervised boiler inspectors in every section of the United States. Also, my opinion is based upon my experience and is free from any prejudice against those following a line of work in which I once earned my living.

Boilermakers are most desirable as inspectors of shop work in new construction; in fact, engineers often prove unsatisfactory at such work. They are also found most desirable in locomotive-boiler service inspections, because the average stationary engineer knows little of locomotive-boiler design or locomotive operating conditions; and the locomotive engineer frequently does not know what is under that nice, shining jacket. But in the inspection of stationary boilers in service, which comprises the bulk of boiler inspection work, the good stationary engineer is supreme, because he not only knows how the boiler is constructed and why, but is familiar with the operating conditions that affect its safety and serviceability. To a surprising degree he is a boilermaker, a bricklayer, a steamfitter, a chemist, a machinist, an electrician, and in fact an expert in every line of work affecting the boiler.

For this reason Mr. Johnson is not correct in saying that there are many capable engineers who would not develop into good boiler inspectors. I want to say emphatically that any stationary steam engineer who is not possessed of the technical ability to become a good boiler inspector has not yet earned the right to be called a capable engineer. I say "technical ability" because we must recognize deficiencies due to physical proportions, disposition, etc. J. L. RALEIGH.

San Francisco, Cal.

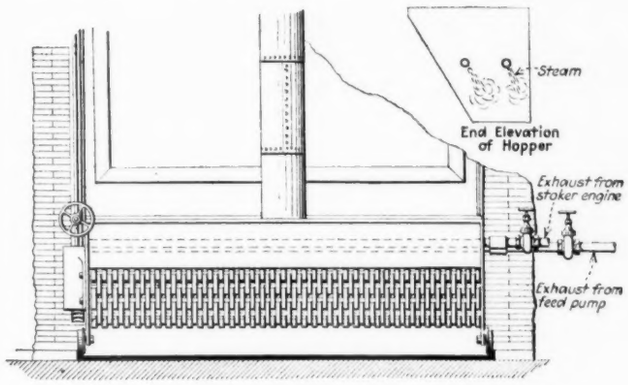
Using Exhaust Steam To Moisten Fuel

A set of water-tube boilers in a manufacturing plant is equipped with chain-grate stokers fired with bituminous screenings. It has been found that the fuel burns better when it is fed to the grate in a moist condition than when it goes in dry. Clinkering of the ash and production of smoke are diminished. Formerly, the requisite moisture was imparted to the fuel by turning a stream of water from a hose into the stoker hoppers each time the hoppers were replenished through the chutes from the bunker overhead.

As an improvement on this method the engineer devised the arrangement shown in the sketch. Two sections of 2½-in. pipe were cut just long enough to fit lengthwise in each hopper. A row of ⅝-in. holes were drilled in a straight line, 3½ in. apart, along each of these sections. The two pipes were then supported side by side in a plane about midway of the depth of the hopper, with the perforations discharging toward the opening through which the fuel flows to the grate.

Steam exhausted by the stoker engine and by the feed pump is conveyed through separate pipes to an exhaust main that connects with an open feed-water heater. Branches were run from these exhaust pipes and connected to the perforated pipes in the stoker hoppers. A back-pressure valve was, however, inserted in each exhaust pipe near its junction with the main, and a gate valve was attached to each branch connection.

The quantity of exhaust steam discharged into the mass of fuel in each hopper is regulated by means of



EXHAUST STEAM PIPING IN STOKER HOPPER

the gate valves. When the gates are wide open, the fuel gets all of the exhaust, but when they are partly or entirely closed, a portion or all of the exhaust goes through the back-pressure valves into the main. The exhaust steam supplies ample moisture for the coal even when the maximum rate of firing is in progress, and the fuel, as fed from the hoppers, is heated to a temperature of about 150 degrees. A. J. DIXON.

St. Louis, Mo.

Opening and Closing the Blowoff

In the correspondence on page 232 of the Aug. 9 issue of *Power*, there appears to be much variance of opinion regarding the proper method of operating a double blowoff combination. The recommendation of the manufacturers, who were the first to offer to the trade a double blowoff combination, known as the tandem blowoff valve, consisting of an angle or master valve and a plug or auxiliary valve, might be of assistance in solving this question.

We recommend to purchasers of the tandem blowoff valve that the master valve be located farthest from the boiler. This will permit the packing of the stem of both valves when required, whether the boiler is in service or not. This work can be done with the auxiliary valve closed and the master valve either closed or open.

In blowing we recommend that the auxiliary valve be opened first and the master valve last; in closing off, the master valve should be closed first and then the auxiliary valve, for the following reasons: First, it insures easy operation of both valves. Second, it gives perfect control by the slow-moving screwed stem on the master valve, thus preventing water hammer, excessive surging of water and possible collapsing of the tubes, and third, it gives longer and more satisfactory service from both the master and the auxiliary valve.

Although this method of operating a double blowoff combination is generally followed, and in nearly all cases is recommended by manufacturers of this equipment, many operators of both large and small plants

use the reverse method. Past records would indicate that if the method recommended by the manufacturer is followed, longer and more satisfactory service can be expected from a double blowoff combination.

A. W. CADMAN,
Pittsburgh, Pa. A. W. Cadman Mfg. Co.

We have read with interest the article of Mr. Fink of the Homestead Valve Manufacturing Co. and also the Editor's note.

It has been my idea for some time that the proper way to install and operate blowoff valves of the type mentioned is to place the angle valve next to the boiler, and the cock or everlasting valve beyond it. It is undoubtedly the best practice to blow down with a slow-opening screw stem valve, as it is the safest. The reason for the two valves in the blowoff line is, first, for safety, and second, to enable the operator to maintain these valves tight so as to improve the economy. If, therefore, the cock or everlasting valve is placed beyond the angle valve and is opened before blowing and closed after blowing, there should be very little wear on this valve and it should be an easy matter to maintain it tight.

The angle valve is usually a special valve for blowoff work and built to withstand the wear and tear of blowing, and therefore, the leakage of this valve should not be very severe at any time during the operation of the boiler. This would enable the operating engineer to remove the cock or the everlasting valve from the line while the boiler is in operation and grind it in or fix it up so there would be no wastage of hot water while the boiler is operating, and the cock would still not be under severe service, as the opening and closing would occur when there is no blowing, except what little leakage might get by the main blowoff valve.

B. M. HERR, District Manager,
The Edwards Valve & Manufacturing Co.
Pittsburgh, Pa.

Confusion of Engineering Terms

Having read the article on page 226 of the Aug. 9 issue of *Power*, I wish to add the following, as comprising terms that are commonly used by working engineers.

Formerly, when a slide-valve engine was mentioned, we knew exactly to what the expression referred. It meant a steam engine with a fixed eccentric, driving a D-slide valve, thus giving a fixed cutoff. The speed was regulated by a throttling governor. Now the same term is applied to engines with balanced, multiport, piston or any other valves that slide, whether the speed is regulated by a throttling governor or otherwise.

A variable cutoff used to mean a cutoff valve riding on a main steam valve, by means of which the point of cutoff could be varied by the engineer while the engine was in motion, by regulating a handwheel outside of the cylinder. It is now used to describe a cutoff operated by a shaft governor or any other device, without attention from the engineer.

When an automatic engine was mentioned, it meant any kind of a steam engine on which the cutoff was performed by the governor, according to the load. Now it is frequently used to designate a short-stroke engine running at high speed, with a shaft governor.

Dealers in machinery advertise that they have "Corliss and automatic engines" for sale. As the Corliss is one of the best known types of automatic engines, it is evident that they mean both low- and high-speed engines.

Engineers frequently state that the valves on their engines leak, when they mean that the stuffing boxes around the valve stems allow steam to escape. They do not know whether the valves leak or not.

While discussing the need of more or less compression, engineers use the terms "running high or low" pressure, when they mean "non-condensing or condensing," as the steam pressure is not changed.

We are told that if a condenser is added to a non-condensing engine, the same load can be carried with less fuel. In reality the total load is less, as the condenser takes off enough back pressure to reduce the forward pressure by twelve pounds or more, hence the load is less, consequently less steam is used.

Tables are published that give the mean pressure of expanding steam. They are commonly used to determine the indicated power of a steam engine, which is not correct. With a condensing engine running with a high vacuum, they give a slightly higher rating than can be secured in practice. If applied to a non-condensing engine, the result is much too high.

An engineer will claim that he is using a single-acting steam pump to feed his boiler. Investigation shows that he has a simplex pump, or in other words a pump with only one water cylinder, but it is double-acting. Another will tell about using a triple-acting power pump, when he means a power pump that is fitted with three cylinders, but all of them are single-acting.

New Haven, Conn. W. H. WAKEMAN.

Water Circulation in Steam Boilers

We have read with considerable interest the communication on page 189 of the Aug. 2 issue of *Power* by Mr. Gillette.

For a number of years we have expended a large sum of money in apparatus and models to show the circulation in water-tube boilers, and these models have been exhibited before a large number of engineering associations by our Mr. Lippincott. He has found that considerable curiosity exists regarding the circulation in the return-tubular boiler, and for this reason we have constructed a number of glass models of the return-tubular type, to be operated with electric heating elements, for our lectures to be given during the coming winter. The results of our experiments will be presented through the columns of *Power*, when they are completed.

We are also doing considerable experimental work regarding the advantages of small or large tubes in return-tubular boilers; the letters that have recently appeared in *Power* do not seem to have offered much in the way of a solution of this problem.

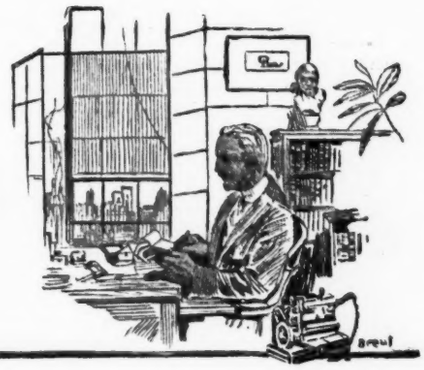
New York, N. Y. E. KEELER COMPANY.

Peculiar Design of Simplex Pump

On page 190 of the Aug. 2 issue of *Power* O. W. Miller describes a pump used by the Tide Water Oil Co. I will advise that it is a Blake, but I believe Mr. Higgins has changed the valve gear a little. There are a number of these pumps in use, and they are very good for certain work. GEO. J. ADAMS.

Norwalk, Conn.

INQUIRIES OF GENERAL INTEREST



Equalizing Rheostats for Generators in Parallel.—What is an equalizing rheostat, and how is it connected for parallel operation of direct-current generators? M. E. A.

The equalizing rheostat is a small auxiliary rheostat frequently used in connection with a Tirrell voltage regulator, to compensate for differences in the characteristics of generators operating in parallel. When the impedance of the field windings varies considerably in the different machines, some may be more sensitive and respond more rapidly to the action of the regulator. It then becomes necessary to moderate this action by the insertion of an adjustable resistance in series with the vibrating contacts, thus slightly reducing the field current during the time that the regulator contacts remain closed. This adjustable resistance is termed the equalizing rheostat.

Air in Water Reduces Pump Suction Capacity—How does air in water affect the capacity of a pump with suction lift? W. L. S.

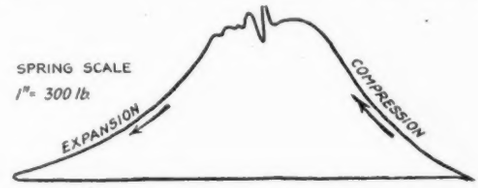
Water under atmospheric conditions contains about 2 per cent air in solution, and when the pressure is reduced, as by partial vacuum in a pump suction, this air will expand. Under a suction lift of 17 ft. the initial 2 per cent of air would expand to 4 per cent., and with a suction lift of 28 ft., which is equivalent to an absolute pressure of 6 ft. of water, the original 2 per cent of air would expand to $34 \div 6 \times 2 = 11.3$ per cent. The air then would fill 11.3 per cent of the water cylinder with corresponding reduction of pumping capacity. The reduction of capacity usually is not as much in practice because the water so quickly passes through suction pipes of ordinary lengths that there is not sufficient time for the air to be liberated.

Pounding of Crude-Oil Pump—We have a duplex power pump direct-connected to an oil engine for pumping crude oil to a tank against a head pressure of 60 lb. gage, and there is frequent breakage of the pump head. The suction is taken from a gravity line several miles long. Part of the day the suction line pressure is increased by a pump at the head of the line and delivery to our tank pump is at a low gage pressure, but during nearly one-half of the time the suction presure is below the pressure of the atmosphere. What may be the cause of trouble and the remedy? C. E. W.

Pumping oil with suction lift or with such speed of pump-piston displacement as to reduce the suction pressure in the pump chamber below pressure of the atmosphere cannot be performed successfully because, just as in pumping hot water, there will be liberation of a vapor that will wholly or partly fill the pump cylinder to exclusion of the liquid, accompanied by racing and pounding. This would be reduced by lowering the pump and also by running at a slower speed and by the employment of an air chamber on the discharge side of the pump. If there is a pounding when the suction gage indicates pressure above the atmosphere, with wide fluctuations of the gage hand, some of the trouble may be attributed to the sudden arresting of motion of the oil in the long suction pipe at each reversal of stroke of the pump, and considerable relief would be afforded by an air chamber on the suction line near the pump.

Diesel Compression Diagram—The diagram was taken from a Diesel engine by pulling the indicator cord by hand, without any reducing motion. What is the reason for the sharp peaks, and is the timing of the fuel valve correct? L. H.

The compression in the cylinder as shown by the height of the diagram is entirely too low, being only 300 lb., and it should be increased to at least 450 lb. by placing fillers under the connecting-rod end. The fuel ignites too late—



after the piston has started on the power stroke. Even if the fuel-valve timing is correct, the low compression may cause late firing, since the time interval between injection and firing depends on the compression. The wavy shape of the combustion line could be caused by the indicator inertia or by the action of the fuel, if kerosene is used.

Breakage of Water Gage Glasses—We have considerable trouble from breakage of boiler water gage glasses. The breaks usually occur a short time after the glasses have been reset after cleaning and sometimes new glasses break with very little use. What is the cause and remedy? C. C. G.

Glass gage tubes are likely to break from expansion if they have been thrown out of line or are too firmly held at the ends from setting up the packing nuts, and the strength of the glass is nearly lost in places where the surfaces may have been scratched, especially along scratches made on the interior surface. To prevent these a wire or other hard material that would scratch the glass should not be used with a swab for cleaning the glass. The swab, consisting of a plug of clean waste or other soft material, should be attached to a piece of twine for drawing it back and forth through the tube. When the glass is loosely held in place by the packings, before being screwed down tight, see that the fixtures are in good alignment and move the glass endwise, so the ends of the tube will extend equally into the stuffing boxes, and have the glass long enough to prevent the rubber rings from being pressed over either end of the tube. In order that the gage glass may not be subjected to undue bending or twisting stresses, screw the packing nuts down no harder than necessary to make a tight joint. If the fixtures are in fair alignment, and good rubber packing rings are used of the right size for the glass, a joint will be obtained tight enough for ordinary boiler pressure by setting the packing nuts down only so hard that the glass can easily be twisted in position when grasped with the thumb and fore-finger of one hand.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Preheat of Boiler-Furnace Air

Much has been heard lately about the use of air preheaters in boiler plants in Europe and especially in England. At the summer meeting of the Institution of Mechanical Engineers a session was devoted largely to power-plant problems, one of the discussions being on this subject.

The discussion is reported in *Engineering* of July 15. It was introduced by W. H. Patchell, who pointed out that C. Wye Williams, in his book on the combustion of coal, pointed out an instance of the use of preheated air in 1842. Air heaters have been largely used in the mercantile marine in connection with forced draft, but he had found it difficult to get detailed results of similar boilers operated with and without air heaters, from which the benefits of air heating could be closely studied. From such data as he had been able to procure the accompanying table has been compiled. Mr. Patchell explained that the excess air had been calculated from Bunte's formula, assuming 18.9 per cent CO_2 would be obtained with no excess air, and the figures were therefore only approximate. The extra efficiency took account only of the heat units returned to the furnace with the air.

When the air supply was cut down to a minimum, the extra efficiency due to the air heater was less than when a large excess of air was admitted. Mr. Patchell thought that retort-type stokers in which the grates are thickly covered, could be safely operated with a hotter air supply than could chain-grate stokers where the fuel bed was thin. The removal of dust from air heaters is a matter to which careful attention must be given.

TESTS OF AIR HEATERS

Date	Hours Duration	Type of Boiler	Heating Surface of Boiler, Sq.Ft.	Grate Area, Sq.Ft.	Type of Stoker	Type of Air Heater	Heating Surface of Air Heater, Sq.Ft.	Lb. of Coal per Sq.Ft. Grate Area per Hr.	Coal Burned per Hour, Lb.	Ratio of Air Heating Surface to Coal Burned per Hour	Temp. of Gases: Leaving Boiler, Deg. F.	Temp. of Gases: Leaving Heater Deg. F.	Temp. of Air: Entering Air Heater, Deg. F.	Temp. of Air: Entering Furnace, Deg. F.	Temp. of Air: Rise in Temp. of Air, Deg. F.	Excess Air over that Necessary, per c.	Extra Efficiency* of Boiler Directly due to Air Heater, per c.	Efficiency of Boiler and Air Heater, per c.	Efficiency of Air Heater, per c.
4.8.98	7	Brown's Marine	975	34.0	Hand-fired induced draft	Ellis and Eaves	900	41.0	1,405	0.64	.....	460	118	295	177	110	...	74.0	..
5.8.98	4	" "	975	34.0	" "	" "	900	50.0	1,702	0.53	.....	442	112	303	191	117	...	60.0	..
28.1.14	4	Stirling	3,660	65.7	Underfeed travelling	Usco	1,800	30.5	2,000	0.90	526	374	68	197	129	28	3.1	85.3†	79
29.1.14	4	Stirling	3,660	65.7	" "	Usco	1,800	33.0	2,150	0.84	564	385	71	202	131	61	4.0	83.6†	69
26.9.13	4	Stirling	6,203	99.0	" "	Usco	2,204	35.5	3,528	0.62	588	383	92	247	155	47	4.2	83.3†	71
16.1.12	6	Woodeson	4,100	77.0	Class "E" underfeed	Usco	2,378	31.0	2,414	0.98	525	...	79	225	146	54	4.2	82.1†	..
17.1.12	4	Woodeson	4,100	77.0	" "	Usco	2,378	42.5	3,275	0.73	591	402	77	230	153	36	3.9	80.5†	76
18.1.12	6	Woodeson	4,100	77.0	" "	Usco	2,378	31.0	2,400	0.99	584	...	88	259	171	69	5.4	80.4†	..
19.1.12	4	Woodeson	4,100	77.0	" "	Usco	2,378	41.0	3,175	0.75	648	...	88	272	184	54	5.3	79.5†	..
5.2.01	13	Marine	2,867	63.3	Hand-fired forced draft	Howden	766	20.5	1,303	0.65	491	396	85	185	100	106	...	82.3	..
21.1.21	8	Belleville	825	38.5	" "	Thermix	755	15.0	585	1.29	572/608	428/471	55	194	138	89	4.7	69.2†	..

* These "Extra efficiencies" only take into account the thermal units returned to the furnace with the air. † These efficiencies include superheaters.

David Wilson thought that there was little evidence that air heaters in lieu of economizers would be a success from the thermal efficiency point of view. He had made tests on two identical boilers, one fitted with a water economizer and the other with an air heater. The boiler had a heating surface of 6,295 sq.ft., while the heating surfaces of the economizer and air heater were 2,400 sq.ft. and 3,132 sq.ft. respectively. The results of these tests showed that 7.22 per cent of the total heat was absorbed by the water economizer and only 4.37 per cent by the air heater. Where turbine exhaust is available for water heating, the increased thermal efficiency from the use of air heaters might justify their use.

W. H. Owen said that comparative tests carried out by D. Rowan & Co., of Glasgow, on their own works boiler of the marine type, which tests extended over a week in each case, showed a 15 per cent saving in coal in favor of the air heater. Seventy-six installations of Howden's hot-air forced draft had been carried out on land. It was mainly in the secondary stage of combustion that losses occurred, and these could be materially reduced if the secondary air were preheated. There was much to be said for a system that tended to perfect the fundamental processes of combustion, and at the same time there were numerous concomitant advantages, of which he mentioned immediate response to overloads, reduction in smoke and soot production and other points. The cost of an air heater and fan would be considerably less than that of a complete water economizer, and there was no danger of explosion of the former.

S. E. Fedden had installed air heaters some twenty years ago and had been able to increase the evaporation of a particular boiler from 11,000 to 14,000 lb. per hour. No trouble had been experienced with the grate bars since these were protected by steam jets. In the case of a Stirling boiler, however, to which the same system had been applied, trouble had been experienced with the rear bank of tubes which were used for feed heating. To avoid this, he had put in a live-steam feed heater and afterward an economizer, but the air heater wore out and corroded away and was not replaced.

Charles Erith said that the problem of air heating as a possible economy in power stations differed materially from its possibilities at sea. He did not think Mr. Patchell's tests could be taken seriously. One of them showed 106 per cent excess air with a thermal efficiency of 82.3 per cent, and most of them were of short duration. At sea it was out of the question to use the type of economizer commonly employed on land, and with regard to air heating in land power stations he thought Mr. Fedden's experience was conclusive. There was a tendency to omit economizers on account of the highly sustained efficiency of modern boilers, and in power stations in which expanded steam was used for feed heating there was no inducement to employ them. In such cases an air heater might be used to recover some of the heat instead of the economizer, but he was in favor of the latter. The heat recovery claimed by Mr. Patchell for air heaters was very small, but with the present high price of coal, small economies had to be considered. It might be possible to employ an air heater at the rear of the water economizer, but the speaker doubted if the heat recovered would compensate for the extra power absorbed by the fans. The air heater would, of course, recover more heat if placed between the boiler and the economizer, but it would do this mainly at the expense of the heat recovered by the economizer. In modern power stations it was quite easy to obtain perfect combustion with cold air, so that the question of employing an air heater depended entirely on the heat units it returned to the system.

S. Utting thought that the column in Mr. Patchell's table giving the extra efficiency due to air heating was liable to misinterpretation. He assumed that it represented the heat

units returned to the boiler and that it was based on the heat units in the coal as fired, which understanding Mr. Patchell remarked was correct. Mr. Utting thought that Mr. Fedden's experience was similar to those in connection with many other engineering developments. Superheaters had been introduced and abandoned, but were now in general use. As between economizers and air heaters the advantage would lie with that method which gave the lowest capital and running costs. It might be possible to reduce the size of the economizer in order to lessen the capital cost and recover the remainder of the heat by air heaters, and in some installations the heated air could be used for other purposes instead of being supplied to the furnace. At a paper mill in France half the heated air was used in furnaces and the other half for purposes for which live steam would otherwise have been employed. In power stations there is certainly a tendency to dispense with economizers, and Mr. Utting thought that owing to the higher pressures likely to be employed in the future it would be necessary either to use steel tubes instead of cast-iron tubes for economizers or to replace them by air heaters.

G. A. Tansley referred to some tests that he had made on two Lancashire boilers fitted with Meldrum furnaces, one of which had steam jets without an air heater and the other had an air heater without jets. The jets took about 7 per cent of the steam, but the boiler on which they were fitted supplied more steam to the works than the other. The fires with the steam-jet furnace were well open, and the CO_2 recorded was about 14 per cent with no CO, whereas with the hot-air furnace the fires required constant cleaning and 2 per cent of CO was present in the flue gas. Although the hot-air furnace saved the 7 per cent of steam supplied to the jets, the advantage was on the side of the steam-jet furnace without the air heater to the extent of about 1 per cent.

In closing the discussion, Mr. Patchell said that with large turbo-generator sets and steam-driven auxiliaries, a certain amount of exhaust steam was available for water heating. With large boilers there is not much for economizers to do and they are consequently cut out of the equipment, but as the price of coal goes up it becomes necessary to consider further economies. For high pressures steel-tube economizers would be necessary, and it would pay to install them although that would not have been the case a few years ago. Air heaters had been sold on their merit, but there seem to be no real figures as to their performance. With regard to his analysis of such figures as he had been able to obtain, he admitted that there were numerous differences that affected the results. The coal, for instance, was not always the same, and if the ash was fusible the combustion might be worse when hot air was supplied under the grate. There were also difficulties in connection with the estimation of excess air. He had, however, obtained the most reliable that he could and analyzed them as carefully as the nature of the data permitted. With regard to the Lancashire boiler trials referred to by Mr. Tansley, he thought there must be some difference either in the coal or the draft.

Indiana Utilities Combine

Eight public-service corporations in Indiana, most of them electric-power companies, are being consolidated into the Indiana Electric Corporation. Articles of incorporation have been filed and the Public Service Commission has been petitioned for authority to consolidate about the Merchants Heat and Light Co., of Indianapolis, the other seven utilities, whose property is said to be worth approximately $18,250,000. The territory served by these corporations takes in a great number of cities, towns and rural districts in fourteen counties of the state, embracing a population of about 900,000.

John W. McCardle, chairman of the Public Service Commission, in speaking of the proposition, said: "I hope that the project may go through, for it will be a great thing for Indiana. It is a big step forward in public-utility circles and will serve thousands of farmers, taking to them all the advantages of those in the city who have access to electric current." He said also that engineers will be put to work soon, making a survey of the properties involved, and that when this is completed the commission will fix a date on which to hear the petition.

The project is backed by the Joseph H. Brewer interests, which took over the Merchants Heat and Light Co. in 1914. Mr. Brewer is now president of the American Public Utilities, at Grand Rapids, Mich., and has handled a number of cases of similar nature and magnitude in other states.

The first part of the program to be carried out consists in the electrical interconnection of the various plants involved, but it is planned that eventually there shall be a central plant of 30,000 kw. capacity on the Wabash River, near Terre Haute. This site for the plant was selected on account of its convenience to the coal mines and also, of course, on account of the condensing water afforded by the river. The plant is to be designed for 180,000 volts and will be tied in with the transmission system that is to be established in the meantime.

Brazil to Have Big Dams

An engineering project of large proportions is to be undertaken in Brazil for the purpose of providing water storage for the semi-arid states of Ceara and Parahyba. Five large dams are contemplated, requiring the use of nearly a million cubic yards of concrete and producing reservoirs that are planned to be the largest in the world.

The rainfall in this part of Brazil, which is not far south of the Equator, is about 30 in.; it is concentrated, however, in a rainy season that lasts about four months in the year. In dry years the rain comes intermittently and is quickly evaporated by the extreme heat. These conditions result in severe droughts; hence the proposed system of dams, which will supply water for drinking purposes and for irrigation.

The Brazilian Government is handling the project and has retained Dwight P. Robinson & Co., Inc., New York City, engineers and constructors, to supervise the work. The project is considered comparable, both in nature and in ultimate importance, with the irrigation work carried on since 1903 by the United States Government.

Fuel Economy of Automobile Engines

In the early days of the automobile, a favorite topic for discussion was the influence of spent gases that were allowed to remain in the clearance space at the end of the exhaust stroke. This dilution of the fresh charge was considered to have a bad effect on the power developed, as is evidenced by the number of scavenging devices that were developed. Most of these devices have been discarded and new methods are being suggested for adding exhaust gas to the induction system, thus increasing the amount of inert gas in the cylinder.

In adding exhaust gas to the induction system, a higher thermal efficiency has been the goal. Some investigators have found that increasing the amount of inert gas in the charge tends to prevent fuel knock, and hence enables high compression ratio to be employed. Since thermal efficiency depends upon the expansion ratio, which in the conventional engine equals the compression ratio, it should be higher with a higher compression ratio. Full throttle tests apparently show such to be the case and from these results it has been concluded that the addition of exhaust gas will be even more beneficial at part throttle. Since the automobile engine in service is operated at part throttle most of the time, it is under this condition that economy of fuel consumption is most important. Consequently, the Bureau of Standards has given considerable attention to the effect of admitting exhaust gas under such circumstances.

The Bureau concludes that the dilution of the charge by the spent gases remaining in the clearance volume makes it impossible at low throttles to employ those air-fuel ratios which, if they could be fired, would yield the maximum efficiency. If the exhaust gas that is present during normal operation forms a barrier to the use of high efficiency mixtures, then surely the designer ought to avoid any devices for adding still more dead gas to the charge.

Project for the High-Tension Distribution of Electrical Energy Throughout France*

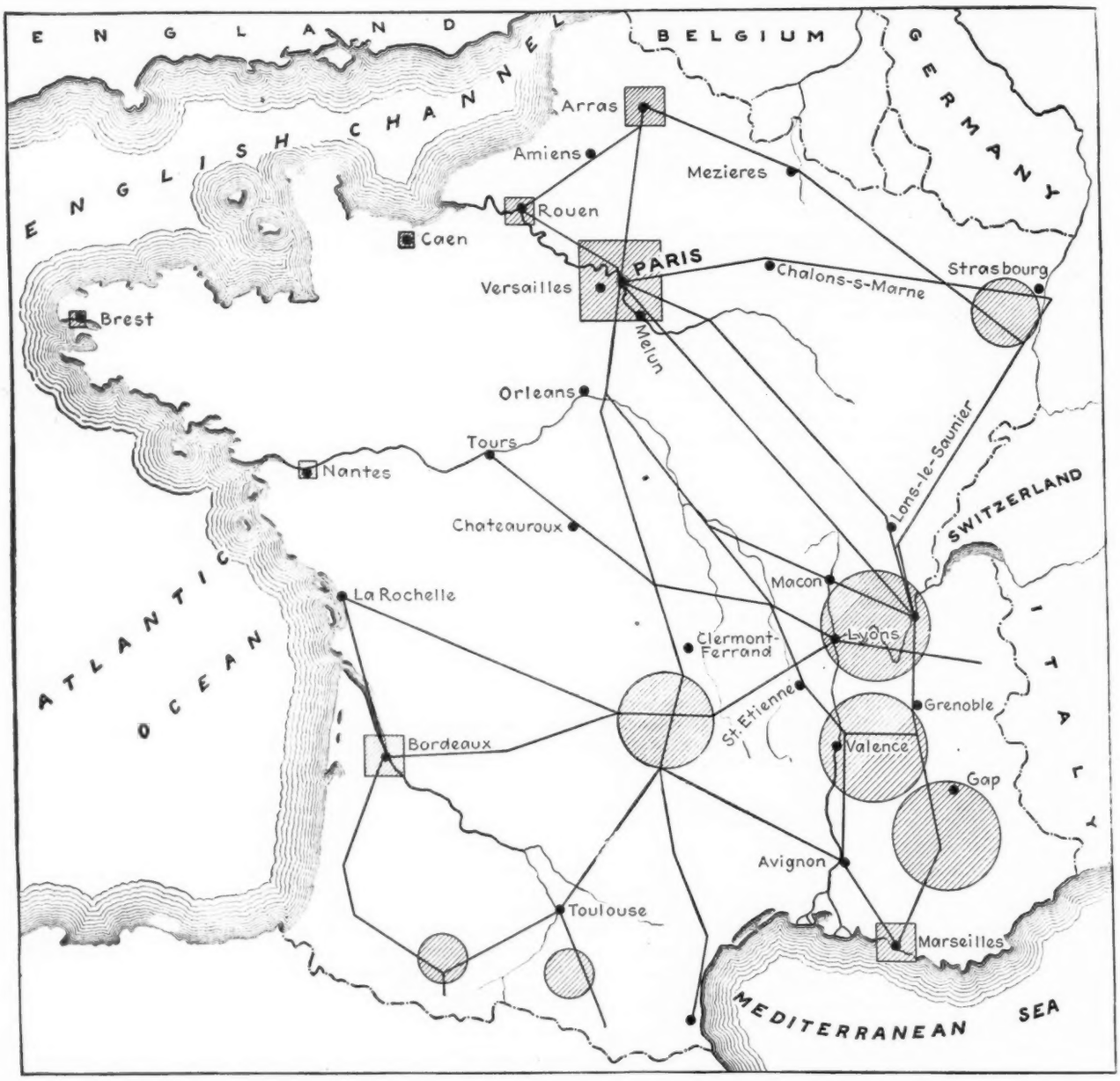
It is proposed to develop to the fullest practical extent the water-power resources of the country and construct large steam stations at or near the coal mines to consume refuse coal. This energy will be transmitted at 150,000 volts to the large industrial centers. On the map the large blocks of available hydro-electric power are indicated by a shaded circle, the diameter of which is proportional to the total power included within the circle. The maximum amount of energy that could be produced in steam plants has been estimated and indicated by a shaded square, the side of which is proportional to the total power to be made available in that region. The transmission system is indicated by heavy lines.

The total amount of energy estimated available would be about 4,500,000 kilowatts, 3 millions water power and 1.5 millions steam. The outstanding features of the plan are are as follows:

A. Those plants located close together will be interconnected and their output transmitted to the points of utilization. There is to be no interconnection between different transmission lines at the receiving end, however, in order to avoid troubles in voltage control and to safeguard the individual rights of distributing companies. If the power demand in any one center is of such magnitude that it must be supplied from several sources simultaneously, these sources will not be paralleled but kept entirely separate, and the customers will be divided up between them.

B. It is further proposed to store off-peak energy in the steam plants by heating and storing feed water for use during the peaks.

*Abstract of article by Ch. Duval and Ch. Lavanchy, published in *Revue Generale de l'Electricite*, May 31, 1921, page 733.



MAP OF PROPOSED HIGH-TENSION DISTRIBUTION OF ELECTRICAL ENERGY FOR FRANCE

Circles indicate available water power, the diameter being proportional to the total amount in that region. Squares indicate estimated steam power to be made available by execution of this project, the side of the square proportional to the amount of power. Available water power: Southeast, 2,500,000 hp.; Southwest, 800,000 hp.; Central, 700,000 hp.; East 500,000 hp. Estimated steam power to be made available: Paris, 600,000 hp.; Arras (mines), 300,000 hp.; Bordeaux, 300,000 hp.; Marseille, 300,000 hp.; Ronen, 200,000 hp.; Nantes, 100,000 hp.; Brest, 100,000 hp.; Caen, 100,000 hp.

The Smith Continuous Carbonization Process

There has been a good deal of discussion of recent years as to the relative merit of different systems of coal carbonization. At one end of the scale are the high-temperature systems, which are usually chosen from a desire for the highest possible gas yield. At the other end are to be found the low-temperature methods, which are primarily concerned with a larger production of valuable liquid distillates, and of a useful smokeless fuel. The question turns largely on the form in which the products are best marketable, and if the market changes so as to make a smokeless fuel or fuel oil the chief interest of the carbonizing company, the low-temperature method may come into its own.

Where gas of itself is not the first consideration, other systems undoubtedly have good claims to attention, owing to the value of the low-temperature byproducts. One of these, which has been in use for two years, is the Smith continuous system of carbonization, which is in reality a dual process. This system was recently described in the paper read before the Society of Chemical Industry by G. H. Thurston and was reproduced in *Engineering*, from which this material has been taken.

The Smith process is, as stated, a dual process, the coal being first subjected to low-temperature distillation, after which the solid residue is again treated at high temperature to produce a solid fuel known commercially as "Carbocoal." The plant as erected at Clinchfield, Va., is completely equipped with labor saving devices. The coal is delivered from the railway cars into a low-level hopper or bin, from which it is carried by a belt conveyor to a crusher. This machine reduces it to about three-eighth-inch size, after which the coal is elevated to the top of the primary retort building. The small coal is fed mechanically into the retort at one end, and after being submitted to the low-temperature distillation process, is discharged at the other through a water seal. The material on leaving the retort consists of a spongy mass, which is next delivered to a conveyor running the length of the retort building to a second conveyor, which delivers the partly coked material to the storage bin. Here the material is again crushed to one-eighth inch size, mixed with 8 to 10 per cent, by weight of pitch, and the mass is then taken to a fluxer, in which the pitch and solid are mixed with the assistance of steam, being finally delivered to the briquetting press. The latter is of the roller type and the product in the form of egg-shaped briquettes of three ounce weight is dropped onto a long conveyor. By the time the briquettes arrive at the end of the conveyor they are cooled off and set, and can be delivered to a storage bin in the second retort house. Here the briquetting material is subjected to a further carbonization process at a high temperature, being delivered from the bin to the retort by a conveyor. From these retorts another car runs the discharged briquettes of carbocoal off to a separate building, where they are quenched and stored for distribution.

In the first retort are placed two revolving feeders, and the gas is drawn off from the retort and led to a gas main above. The solid material discharge is termed semi-carbocoal. Stripped gas is used for heating the retort and the air supply is preheated. Treatment in the primary retort occupies from two to three hours. The secondary retort is a modified type, rectangular in cross sections, each section having three compartments. The briquettes are subjected to a temperature of about 1,090 deg. centigrade 1,994 deg. F.) in these retorts.

The products vary considerably with the class of coal. This, of course, is natural, and has been one of the troubles against which low-temperature carbonization has to contend, as many coals are not suited to treatment by this method alone. It is claimed for the Smith system that a much wider range of coal, including even many lignites, is permissible on account of the dual treatment of the solid product, the final carbonization resulting in a good, free-burning, smokeless fuel from original coal that would be quite unsuitable for low-temperature treatment alone. The low temperature of the first retort results in the valuable liquid and other products associated with distillation under such conditions. The quantity and quality, of course, vary with the coal. With a high-volatile Pittsburgh coal the following are obtained per ton in the first retort:

Gas 5,600 cu.ft.; tar 22.4 gallons; sulphate of ammonia 2.24 pounds.

From the second carbonization 4,480 cu.ft. are obtained, with 5.6 gallons of tar and 20 pounds of sulphate of ammonia. It will be thus seen that the large production of tar oils of the low-temperature process is supplemented by a further gas yield and a high output of sulphate of ammonia in the secondary course of the process. The total of 10,800 cu.ft. of stripped gas is used for heating the retorts, with the exception of some 2,200 cu.ft. that are used in the by-product plant and are sufficient to work it without other fuel. The twenty-eight gallons of tar yield eighteen gallons of distillate, the balance being pitch, which is utilized in the briquetting. The briquettes, after passing through the secondary retorts, contain volatile matter to from 3 to 4 per cent, leaving them very hard, so that they stand handling and can be safely used in place of hard coke in furnaces. The actual heating efficiency of the finished carbocoal is claimed to be as high as 94 per cent of that of the coal from which it is made.

The gas of the first retort has a value of about 700 B.t.u. per cu.ft. and that from the final retort a value of about 400 B.t.u., the average for the two being about 548 B.t.u.

As to the value of carbocoal, some published test figures relating to tests by the United States Navy show that one pound of carbocoal evaporated 9.09 pounds of water from and at 212 deg. F., compared with 9.59 pounds of water from the original coal from which the fuel was made. Some of the advantages claimed for the fuel is the strength of the briquettes, resulting in immunity from dust and spontaneous combustion. It bulks only slightly more for equal heating value than coal, and is, therefore, suited for bunkering or for transportation by rail. The crushing strength of the briquette at high temperature is indicated by test to be very good, the figure of 943 pounds at a temperature of 2,530 deg. F. being quoted.

The Use of Peat for Power in Germany

Germany's coal shortage, which followed closely the end of the war, aroused the nation to the need of saving coal, with the result that the use of peat in large electric central stations as a conservation measure ranked second to nothing but hydro-electric development. Later, however, a reaction to this enthusiasm followed upon the heels of the general conviction that the coal-saving movement had overshot its mark. The peat-producing industry is at present inactive.

The apparatus and methods that have been developed for the obtaining and preparing of peat, however, are interesting, not simply as a matter of history, but also because the future will undoubtedly see extensive and increasing use of peat in Germany and, eventually, in this and other countries.

Germany has seven large peat districts: One on the North Sea coast, four on the Baltic coast, and two in Upper Bavaria, near the Tyrolese frontier.

While the raw product differs widely according to localities, the pure peat obtained after preparation shows little variation in its chemical composition. The contents of the average peat are the following:

		Per Cent
Carbon		55 to 60
Volatiles	Oxygen	29 to 34
	Hydrogen	5 to 6
	Nitrogen	1 to 4
	Sulphuric acid	½ to 1.5

and small parts of potash, phosphoric acid and calcium.

The peat obtained contains as a rule 95 per cent of moisture, which can be reduced by draining of the fields to not less than 85 per cent. For reducing the moisture to the maximum of 25 per cent allowed, the old air-drying process is still practically the only method generally favored. A number of firms have devoted themselves to constructing peat-drying machinery, and several types have been com-

pleted, or are now being tested, without being able to supplant the simple method of air-drying.

To obtain peat in large quantities, machinery is now mostly used, although in some localities human labor is still employed to a large extent. Where peat has to be cut under water, the old-time peat-cutting machine is used, from the primitive type to elaborate power-driven machinery. The principle upon which such machines work, however, is practically identical in all types. Upon a frame mounted on rollers and resting on tracks is placed the cutting mechanism, consisting of a box-shaped cutter 10 to 12 in. square. This cutter is driven down into the peat, either by hand or by machine power, by means of a rack-and-pinion motion, the length of the rack corresponding with the working depth for which the machine is built. These cutters have as a rule a lance-shaped pilot cutter, which serves as a support for true vertical cutting, at the same time helping to find hard objects in the ground threatening to damage the cutting box, like stones and petrified wood. Most types of cutting boxes have a knife for horizontal cutting at the bottom, the blade of which is bent in a circle, and which is pressed against the back wall of the cutting box at the down stroke, in order to offer as little resistance to the vertical cutting as possible. When the cutting box has reached the lowest point, this circular knife is put into operation by a lever motion, horizontally cutting through the peat and serving as the bottom of the cutting box when hoisting. The cut-out peat is then extracted and cut into sods of from 4 to 5 in. thickness.

Ohio to Accept Boilers Stamped by National Board

Of outstanding importance in the standardization of boiler-inspection work is the fact that the Ohio Board of Boiler Rules has recently amended its rules to permit the acceptance in Ohio of boilers stamped in accordance with the requirements of the by-laws of the National Board of Boiler and Pressure Vessel Inspectors. This means that Ohio has officially recognized the National Board as a functioning organization, and has given the same effect and authority to inspections made upon boilers in other states under the rules of the Board as to inspections made under Ohio laws within the state.

So far as is generally known, Ohio is the first state to take such action. Its recognition of the authority of the National Board of Boiler and Pressure Vessel Inspectors, therefore, is a notable event.

As would naturally be expected in the case of an organization whose members are widely separated in different parts of the country, the Board has come into existence slowly. The preliminary organization was effected Dec. 2, 1919, but no formal meetings were held from that time until Feb. 2, 3 and 4, 1921, when a final organization meeting was held at Detroit, a constitution and by-laws were adopted and permanent officers elected.

The membership of the Board comprises the heads of the boiler-inspection departments of those states and minor political sub-divisions of the country that have adopted the A. S. M. E. Boiler Code or have incorporated it in their boiler-inspection laws. It has, therefore, no authority of its own, save what is granted to it by official action of its members. It is the ultimate object that the action recently taken in Ohio shall be repeated in every political division of the country where the A. S. M. E. Code is accepted as standard. When this has been done, much red tape and expense in inspection work can be done away with, and it will be possible to devise a uniform set of rules and regulations for the inspection of steam boilers that will make easier the work of the manufacturer, the inspector and the user. The personal co-operation that will naturally arise among members of the Board in carrying out its provisions will also, of course, be helpful.

New Publications

TESTS OF CENTRIFUGALLY CAST STEEL. Technologic Paper No. 192 of the Bureau of Standards, Washington, D. C. Paper, 7 x 10 in.; 22 pages. Price, 10 cents.

This bulletin describes tests made on castings manufactured by the Millspaugh centrifugal process. The physical and chemical properties in various portions of the castings were investigated to discover what variation, if any, existed.

The results obtained indicate the possibility of subsituting heat treatment for forging in this type of casting.

THERMODYNAMICS. By J. E. Emswiler, Professor of Mechanical Engineering, University of Michigan. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City. Cloth, 6 x 9 in.; 266 pages. Price, $3.

This book was prepared primarily as a textbook for use in engineering schools. It differs notably from the ordinary book on thermodynamics by starting right off with steam, the steam tables and an outline of the elements of the steam-power plant. After steam comes vapor refrigeration; then the study of permanent gases, mixtures and air heat engines. Discussion of such abstract subjects as Laws of Thermodynamics and the Kinetic Theory of Heat is reserved for the last part of the book. The book should be of value not only to the engineering student, but also to the practicing engineer who is reasonably familiar with elementary mathematics and desires to "brush up" his thermodynamics. Both students and engineers can get valuable drill from the problems given at the end of each chapter.

THE USE OF POWDERED FUEL UNDER STEAM BOILERS

This pamphlet is a most complete summary of powdered-coal progress and is in the form of a speech that was read by H. D. Savage, of the Combustion Engineering Corporation, New York City, before the recent meeting of the American Iron and Steel Institute. The address goes into detail regarding the different types of equipment and actual results obtained up to the present, and is in a sense, a story of powdered-coal progress. Some of the test records made in one of the corporation plants subsequent to the reading of the paper have been widely quoted, not alone because of the exceptional results shown, but also by reason of their undoubted authenticity and conservation, which are assured by the fact that the tests upon which they were based were run by the United States Bureau of Mines under the direction of John Blizard, assisted by Henry Kreisinger, research engineer of the Combustion Engineering Corporation. Thus official and authentic data on results are published in this pamphlet, which is well illustrated, and the results of various tests are tabulated.

Personals

W. S. Richmond, consulting engineer on hydro-electric and general hydraulic problems, has moved from Detroit to Buffalo, where he will continue his practice.

A. H. Sweetnam, for the last four years connected with Stone & Webster as electrical engineer, has resigned to become assistant superintendent of the electrical engineering department, the Edison Electric Illuminating Company of Boston. Mr. Sweetnam is a member of the A. I. E. E. and the National Electric Light Association, and also of the Boston City, Engineers' and Woodland Golf Clubs.

Business Items

The American Steel and Wire Co., Chicago, Ill., has appointed H. S. Durant and M. W. Floto assistant sales agents at the Detroit office to succeed M. Whaling and T. J. Usher, Jr., resigned.

The Morgan-Gerrish Co., 501 South Sixth St., Minneapolis, Minn., has announced that L. L. Smith, formerly Minneapolis branch manager of the Under-Feed Stoker Company of America, is now associated with them. Mr. Smith will continue to represent, through the Morgan-Gerrish Co., the Under-Feed Stoker Company of America, as well as several other manufacturers of allied lines of power-plant equipment.

The Whitlock Coil Pipe Co. is now manufacturing an all-steel steam superheater, constructed with heavy open-hearth steel headers and heavy-gage seamless steel tubing, the heating elements being expanded into the steel headers. The openings opposite the expanded tube terminals are closed by means of patented gasketless removable steel caps.

The Barto-Phillips Co. has been formed by Edmund L. Barto and Harry J. Phillips, C. E., formerly sales engineer and chief engineer, respectively, of the New York office of the Austin Co. The new company has established offices at 280 Madison Ave., New York City, and will engage in the engineering design, construction and exportation of all classes of industrial buildings including power house and equipment requirements.

Trade Catalogs

Vogt Brothers Manufacturing Co., Louisville, Ky., has issued a new bulletin describing its line of hand-operated stokers and giving directions for operating them.

The Orton & Steinbrenner Co., Chicago, Ill., has put out a new catalog, No. 19, describing its line of coal crushers and giving some information also on its locomotive cranes.

The Greenfield Tap & Die Corporation, Greenfield, Mass., has issued a new 5x7-in. 396-page catalog, No. 46, which covers taps and dies, screw plates, drills and reamers, milling cutters and pipe tools, and contains a large number of useful tables of tapers, wire gauge sizes, tap drill sizes, etc.

The Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has prepared a revision of its bulletin on Type E direct-current motors and generators. Type E motors are made for either constant- or adjustable-speed conditions, and for standard voltages of 115, 230 and 550. The new bulletin is No. 1106-A.

The Buckeye Machine Company, Lima, Ohio, has issued two new bulletins, Nos. 301 and 302, describing its line of oil engines as designed for municipal light plants and water works, flour mills and grain elevators. The engine is of the medium compression, two-stroke-cycle, semi-Diesel type. Bulletin 301 contains some operating cost figures for a sixty-five horsepower installation in a flour mill.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Aug. 16, 1921	Aug. 23, 1921
Pool 1,	New York	$3.15	$3.00@3.40
Pocahontas,	Columbus	3.00	3.00@3.25
Clearfield,	Boston	2.55	2.15@2.70
Somerset,	Boston	1.70	1.40@1.75
Pittsburgh,	Pittsburgh	2.10	2.00@2.15
Kanawha,	Columbus	2.10	2.00@2.25
Hocking,	Columbus	2.15	2.00@2.30
Pittsburgh No. 8	Cleveland	2.30	2.25@2.35
Franklin, Ill.,	Chicago	3.30	2.25@3.50
Central, Ill.,	Chicago	2.15	2.00@2.75
Ind. 4th Vein,	Chicago	3.10	2.25@2.75
Standard,	St. Louis	1.75	1.75@1.90
West Ky.,	Louisville	2.45	2.25@3.00
Big Seam,	Birmingham	2.15	2.00@2.25
S. E. Ky.,	Louisville	2.35	2.25@2.40

New York—On Aug. 24, Port Arthur light oil, 22@25 deg. Baumé, 4¼c. per gal. 30@35 deg., 5¼c. per gal. f.o.b. Bayonne, N. J.

Chicago—Aug. 20, for 24@28 deg. Baumé, 45@50c. per bbl.; 32@34 deg. 1¾@1¾c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Aug. 22, f.o.b. refinery; Pennsylvania, 36@40 deg. 3¼c. to 3½c. Oklahoma, 24@30 deg. 40c. per bbl., gas oil, 32@34 deg., 1¼c. per gal., 36@38 deg., 1½c. 38@40 deg., 1¾c.

St. Louis—Aug. 23, prices, f.o.b. cars, tank lots; 24@26 deg. Baumé, 35c. per bbl.; 26@28c deg.. 35c.; 28@30 deg. 40c.; 32@34 deg. 1¾c. per gal.

Philadelphia—On Aug. 23, 26@28 deg. Baumé, Oklahoma, 50c. per bbl.; 30@34 deg., Oklahoma (group 3) 70c. per bbl.; 16@20 deg. Seaboard, 3c. per gal.

Cincinnati—Aug. 8, for 22@28 deg. Baumé, 3c. per gal.

Cleveland—Aug. 8, for 22@28 deg. Baumé, 5c. per gal.

New Construction

PROPOSED WORK

R. I., Newport—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids for the installation of refrigerating equipment here. Spec. 4499.

Conn., Hartford—C. F. Luce, Archt., 36 Pearl St., is preparing plans for a 6 story, 150 x 150 ft. garage on Hicks St. About $500,000. Owner's name withheld.

Conn., New Britain—The State Bd. Educ., Hartford, is having plans prepared for a 2 and 3 story school and dormitory at the State Normal School on Camp St., here. About $1,000,000. Guilbert & Betelle, 2 Lombardi St., Newark, N. J., Archts.

Conn., New Haven — Wescott & Mapes, Inc., Engrs., 207 Orange St., are receiving bids for a 1 story, 80 x 80 ft. power house on Temple St. for the Edward Malley Estate, 902 Chapel St. About $150,000.

N. Y., New Haven—C. C. Peck, 721-23 E. and B. Bldg., is in the market for a 220-volt, 3-phase, 25-cycle, 75-hp. motor.

N. Y., New York—D. S. Lang, Archt., 110 West 34th St., has completed plans for a 5 story, 90 x 100 ft. apartment on Valentine and Briggs Aves. About $300,000. Owner's name withheld.

N. Y., Niagara Falls—The Niagara Falls Power Co., is having plans prepared for a transmission line, including hydraulic tunnel and cable installation under streets. About $11,000,000. J. L. Harper, Canal Basin, Ch. Engr.

N. Y., Utica—The State Hospital Comn., Capitol, Albany, will soon receive bids for a 2 story, 70 x 110 ft. cold storage building; about $65,000; also a 1 story, 39 x 160 ft. kitchen building; about $35,000, for the Utica State Hospital, Marcy Division, here.

N. J., Trenton—W. Hankin, Archt., 241 South Warren St., is preparing plans for a 72 x 139 ft. labor temple for the Mercer County Central Labor Union. About $400,000.

Pa., Harrisburg—E. M. Green, Supt., and Bd. of Trustees Harrisburg State Hospital will receive bids until Sept. 5 for alterations to power house and equipment, to include boilers, etc.

Pa., Philadelphia—The city plans to construct a concrete dam to replace wooden structure, also a power house for generating electricity, in conjunction with dam. About $750,000. Carleton & Davis, City Hall, Engrs.

Pa., Philadelphia — Hoffman-Henon Co., Archts., Finance Bldg., will receive bids until Sept. 1 for a 7 or 9 story, 62 x 180 ft. theatre and store building on 11th and Market Sts. for the Stanley Co. of America, Palace Theatre Bldg. About $1,500,000.

Pa., Pittsburgh—The Bd. Educ. will receive bids until Sept. 8 for a 3 story, 130 x 240 ft. elementary school on Perrysville Ave. About $400,000. R. M. Tromble, Ferguson Bldg., Archt.

Pa., Pittsburgh—The Bd. Educ. will receive bids until Sept. 8 for a 2 and 3 story, 77 x 316 and 61 x 66 ft. elementary school on Greenfield Ave. and Alger St. Cost between $300,000 and $400,000. Kiehnel & Elliott, 245 4th Ave., Archts.

Pa., Pittsburgh—The Bd. Educ. will receive bids until Sept. 8 for a 1, 3 and 4 story, 224 x 235 and 504 x 102 ft. high school and annex on Murtland Ave. About $1,500,000. Ingham & Boyd, Archts.

Pa., Pittsburgh—J. Horne Co., Pennsylvania and 5th Sts., is receiving bids for a 7 story, 120 x 200 ft. addition to store on Penn Ave., to cost between $1,500,000 and $2,000,000. B. Jansenn, Century Bldg., Archt.

Pa., Pittsburgh—The Steel City Amusement Co., 801 Wylie Ave., is having plans prepared for a 4 story, 60 x 210 ft. theatre and office building on Centre and Montrose Aves. About $250,000. Simms, Brittain & English, Magee Bldg., Archts.

Md., Annapolis — The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will soon receive bids for boiler plant improvements at the Naval Hospital here. Noted Aug. 9. Spec. 4500.

Md., Baltimore — Hampden Laundry & Ice Mfg. Co., 3648 Hickory Ave., J. H. McFaul, Jr., Secy., is in the market for complete ice manufacturing machinery and refrigerating equipment.

Va., Richmond—W. E. Carter & Co., 500 South Lombardy St., W. E. Carter, Purch. Agt., is in the market for one motor driven pump, capacity 100 gal. per min.

Va., St. Paul—The city will soon award the contract for a 100,000 gal. reservoir, filter plant, etc. Two motor driven pumps, 100 gal. per min. will be installed. W. W. Bennett, Rocky Mount, Engr.

Va., Yorktown—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will soon receive bids for power house, dispensary and reservoir, etc. Noted Aug. 9. Spec. 4498.

Ga., Tifton — Tifton Handle Mfg. Co., W. E. Chandler, Mgr., is in the market for 3, 5 and 8 hp. a.c. motors.

Fla., Tallahassee—The State is having plans prepared for a 3 story addition to the State Capitol on Monroe St., consisting of 2 wings, 50 x 100 ft. each. About $250,000.

Fla., Tampa—The Exchange Natl. Bank, 610 Franklin St., plans to build an 8 to 15 story, 55 x 105 ft. bank and office building, including a steam heating system, on Franklin St. Estimated cost, between $250,000 and $500,000. Architect not selected.

Tenn., Nashville—The State Bd. of Administration, L. S. Pope, Secy., is having preliminary plans prepared for a school for feeble-minded. About $300,000. Marr & Holman, 701 Stahlman Bldg., Archts.

Ky., Middlesboro—Middlesboro Creamery Co., M. H. Thompson, Purch. Agt., is in the market for machinery for use in 40-ton ice plant.

O., Cleveland—The Cutler Turkish Bath Co., Public Sq., is having plans prepared for a 6 story, 40 x 170 ft. hotel, including heating system, at 1122 Prospect Ave. About $300,000. P. Matzinger, Caxton Bldg., Archt.

O., Cleveland—The Cuyahoga Garage Co., c/o G. Deisman, Vice-Pres., 8810 Harvard Ave., plans to build a 2 story, 196 x 350 ft. community center, including a steam heating system, on Bway. and Harvard Ave. About $300,000. Architect not announced.

O., Cleveland—T. Horobin, 2859 Eaton Rd., is having plans prepared for a 4 story, 200 x 250 ft. apartment, including a steam heating system, on Shaker Blvd. near East 128th St. About $350,000. Whitworth & Johnston, 413 Engrs. Bldg., Archts.

O., Ravenna—The Bd. Educ., will receive bids until Sept. 7 for a 3 story high school. About $350,000. Former bids rejected.

O., Shaker Heights — The Moreland Development Co., O. P. Van Swearinger, Marshall Bldg., Cleveland, plans to build a market and garage on Shaker Blvd. About $250,000. A. W. Harris, Schofield Bldg., Cleveland, Archt.

Mich., Detroit—The Fine Arts Comn., W. J. Gray, Pres., 2900 East Jefferson Ave., plans to build a 2 story, art museum including a steam heating system on Woodward Ave. About $3,000,000. P. Cret, Zantzinger, Borie and Medary, 1535 Chestnut St., Phila., Pa., Archts.

Mich., Detroit — The Masonic Temple Assn., c/o F. E. Fisher, Secy., will receive bids until Sept. 15 for a 4 and 6 story, 190 x 350 ft. masonic temple including steam heating plant in separate boiler room, boilers, pumps, ventilating equipment, etc., on Temple and 2d Aves. About $4,000,000. G. D. Mason & Co., 508 Griswald St., Archts.

Mich., Detroit — G. D. Mason & Co., Archts., 508 Griswold St., will receive bids until Sept. 20 for a 3 story, 80 x 325 ft. club house, including a vacuum steam heating plant, on Belle Isle, for the Detroit Yacht Club. About $500,000.

Mich., Detroit — The North Woodward M. E. Church, 1180 Longfellow Ave., is having revised plans prepared for 2 story church, including a steam heating plant, boiler and ventilating equipment, on Woodward and Marston Aves. About $500,000. W. E. N. Hunter, 1436 Washington Blvd., Archt.

Mich., Kalamazoo—The Michigan State Normal (Western) plans to build a 2 story library, including a steam heating system, on Normal Grounds. About $300,000. H. H. Turner, Michigan Trust Bldg., Grand Rapids, Archt.

Ill., Carrolton—The city, c/o I. Lender, Clk., plans to build a municipal electric plant. About $90,000. Engineer not selected.

Ill., Chicago — Bowmanville Natl. Bank, 4800 North Western Ave., is having plans prepared for a 3 story, 75 x 110 ft. bank building, including a steam heating system, on Western and Lawrence Aves. About $250,000. W. G. Uffendell, 39 South State St., Archt.

Ill., Chicago—S. Buchsbaum & Co., 159 North State St., plans to build a 6 story, 100 x 175 ft. office and factory, including a steam heating system, on East Huron and Fairbanks Sts. About $300,000. Architect not selected.

Ill., Chicago—The Chicago Yacht Club, Monroe and Lake Shore, is having plans prepared for a 2 story, 60 x 80 ft. yacht club, including a steam heating system, on Lincoln Park. About $250,000. A. M. Rebori, 410 South Michigan Ave., Archt.

Ill., Chicago—Fantasia Corp., c/o J. S. Aroner, Archt., 25 East Jackson Blvd., is having plans prepared for a 1 story ballroom, including a steam heating system, on 64th and Cottage Grove. About $750,000. M. W. Allen, Pres.

Ill., Chicago — P. Gerhardt, Archt., 64 West Randolph St., is receiving bids for a 7 story, 61 x 100 ft. factory including a steam heating system at 359 Ontario St. About $300,000. Owner's name withheld.

Ill., Chicago—The Home Bank & Trust Co., Ashland and Milwaukee Aves., representing owners, plans to build a 6 story, 72 x 130 ft. store and office building, including a steam heating system, at 1309-15 South Michigan St. About $250,000. Architect not selected.

Ill., Chicago—A. Sandsgren, Archt., 116 East Oak St., will soon receive bids for a 3 story, 160 x 175 ft. apartment, including a steam heating system, on Sheridan Rd. and Lunt Ave., for S. A. Danielson, 5349 North Paulina St.

Ill., Chicago—S. J. Schaeffer, 155 North Clark St., will soon award the contract for a 6 story, 85 x 150 ft. apartment, including a steam heating system, on Kenmore and Belmoral Aves. About $500,000. E. E. Hall, 123 West Madison St., Archt. Noted May 31.

Ill., Cicero—P. Gerhardt, Archt., 64 West Randolph St., Chicago, is preparing plans for a 2 story, 125 x 185 ft. theater including a steam heating system. About $500,000. Owner's name withheld.

Ill., Evanston—The Garrett Biblical Institute, c/o Rev. C. M. Stuart, Memorial Hall, is having plans prepared for a 2 story museum and library, including a steam heating system. About $600,000. Holabird & Roche, 104 South Michigan St., Chicago, Archts.

Ill., Oak Park—The Oak Park Hostel Co., c/o H. Raeder, Archt., 20 West Jackson Blvd., Chicago, has had plans prepared for an 8 story, 150 x 170 ft. hotel, including a steam heating system, on Park and Erie Sts. About $1,500,000. Noted May 23.

Ill., Rogers Park (Chicago P. O.)—J. J. Jensen, Archt., 4815 North Lawndale Ave., Chicago, is preparing plans for a 3 story, 150 x 200 ft. apartment, including a steam heating system. About $300,000. Owner's name withheld.

Wis., Elkhart Lake—The Public Service Co., c/o W. A. Burke, Secy., will receive bids about Sept. 1, for a 1 story, 60 x 110 ft. power house and machine shop and plans to install power machinery, transformers, switchboards and 4 generators. About $100,000. Private plans.

Wis., Hartford—The city will soon receive bids for a 30,000 lb. feed water heater. metering. Cahill & Douglas, 217 West Water St., Milwaukee, Engrs.

Wis., Kiel—The Kiel Woodenware Co., will receive bids until about Sept. 15 for electric and power equipment including generating unit, switchboards, boilers, etc., for new addition, 250 kw. unit.

Wis., Milwaukee — Sonnenberg Sausage Co., 92 Michigan St., is in the market for ice machine and refrigerating equipment.

Wis., Neenah — E. A. Wettengel, 578 Pierce Ave., Appleton, is having plans prepared for a 1 and 2 story, 80 x 555 ft. paper mill including boiler house, etc., on Blair Spring Site, hydro-electric installation. Power machinery and tools will be purchased. About $800,000. Engineer not announced.

Minn., Mankato—The Bd. Educ., will receive bids until Sept. 6 for a 3 story, 170 x 217 ft. high school, including steam heating and fan ventilator systems. About $300,000. G. Pass, Jr., Archt., Rose & Harris, 318 Auditorium Bldg., Minneapolis, Engrs.

Minn., Mankato—The Bd. Educ., E. F. Searing, Clk., will receive bids until Sept. 6 for a 3 story, 168 x 224 ft. junior high school, including a steam heating system. About $350,000. G. Pass & Son, Archts. Noted May 3.

Kan., Leavenworth—The Natl. Soldiers' Home, c/o Captain W. S. Albright, Bway. and Oak Sts., is having plans prepared for a 4 story hospital, including a steam heating system. About $1,000,000. W. P. Feth, 405 Delaware St., Archt.

Neb., Fremont—The Bd. Educ., c/o A. H. Waterhouse, Secy., is having plans prepared for a 2 story, 102 x 166 ft. high school, including a steam heating system. About $250,000. A. H. Dyer & Co., Archts.

Neb., Lincoln—The Bd. Educ., c/o J. G. Ludlam, Secy., is having plans prepared for a 3 story, 168 x 258 ft. Junior High School, including a steam heating system, on 23rd and Vine Sts. About $750,000. Fiske & Meginnis, Bankers Life Bldg., Archts.

Neb., West Point—The city, c/o S. Lindale, Clk., will receive bids until Sept. 1 for an addition to electric light and power plant, including equipment. About $58,000. Kolning & Hollister & Co., Bankers Life Bldg., Lincoln, Engrs. Noted June 14.

Mo., Columbia—The state, c/o Hospital Comn., Jefferson City, plans to build a 3 story hospital, including a steam heating system, here. About $250,000. Architect not selected.

Mo., St. Louis — The Masonic Temple (Blue Lodge), c/o J. Jones, Railway Exchange Bldg., is having plans prepared for a 2 story Masonic temple, including a steam heating system, on Lindell and Spring Aves. About $1,500,000. Eames, Young and A. B. Groves, Arcade Bldg., Archts.

Tex., Houston—The First Baptist Church, c/o R. J. Cummins, Engr., 203 Stewart Bldg., plans to build a 2 story church and office building. About $1,000,000. C. D. Hill & Co., Sumpter Bldg., Archt.

Okla., Comanche — The city is having plans prepared for an addition to municipal lighting plant to include furnishing and installing 180 hp. oil engine, 150 kva. alternator 2,300 volt, 7½ kw. exciter, switchboard, street lighting panel, 3 in. 300 G.P.M. centrifugal pump with 20 hp. motor and a 20,000 gal. fuel oil tank. Municipal Excavator Co., Tulsa, Engrs.

Okla., Pawhuska—The city plans to build an electric light plant, a 750 hp. Disel oil engine will be installed. About $113,000. H. G. Olmsted & Co., Trademans Bk. Bldg., Oklahoma City, Engrs.

Okla., Pryor Creek—V. V. Long & Co., Engrs., Colcord Bldg., are receiving bids for a water purification plant, electric pumping plant, 8 miles transmission line for the city. About $75,000.

Utah, Maple Springs—The Maple Springs Power Co., recently incorporated, plans to build a hydro-electric plant. H. B. Waters, Engr.

Utah, Stockmore—The Great Basin Power Co., Walker Bank, Salt Lake City, is having preliminary plans prepared for a 5,000 to 10,000 kw. hydro-electric plant. H. A. Strauss, Walker Bank, Salt Lake City, Engr.

Cal., Los Angeles—Swift & Co., 922 East 1st St., is having plans prepared for a 1 story packing plant on East 1st. St. About $60,000. Refrigeration machinery will be installed. J. E. Chatem, 922 East 1st St., Supt.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will soon receive bids for boiler plant equipment. Spec. 4494.

Ont., Clifford — The city council, J. R. Aitchison, plans to build an electric light plant replacing the one recently destroyed by fire. Prices wanted on equipment, etc.

Ont., Thedford—The city council, c/o F. Jennings, plans to build a hydro-electric system. Prices wanted on equipment for complete electric lighting and power distribution system. About $18,000. W. C. Tudor, Engr.

Ont., Timmins—The Dept. of Public Wks., Ottawa, will receive bids about Sept. 1 for development of 10,000 hydro-electric hp. in Ft. Matachawan District. About $500,000. Also for construction of dams at Indian Chutes and Ft. Rapids for the purpose of providing navigable water from Elk Lake to the Ft. Matachawan District. About $1,500,000. E. D. LaFleur, Ottawa, Engr.

CONTRACTS AWARDED

N. H., Berlin—The city has awarded the contract for a 3 story, 153 x 168 ft. high school to F. A. Rumery, 21 Portland St., Portland, Me., $265,133.

Mass., Boston—The city has awarded the contract for a 4 story, 43 x 142 ft. hospital on Harrison Ave. to J. Bower Co., 184 Dudley St., $313,000.

Mass., Great Barrington—The Southern Berkshire Power and Electric Co., Upper Main St., has awarded the contract for a dam, penstock and addition to hydro-electric plant in Williamsville section on the Housatonic River to F. T. Ley & Co., Inc., 499 Main St., Springfield. About $150,000. Also the construction of a dam at the Upper Main St. power plant to the E. D. Ward Co., 82 Foster St., Worcester. About $60,000. Noted June 14.

R. I., Forestdale—The Forestdale Mfg. Co. has awarded the contract for a 1 story, 30 x 60 ft. power house at plant to The Eastern Constr. Co., 660 Winter St., Woonsocket.

Conn., New Haven—Yale University has awarded the contract for a 3 story laboratory on Prospect St. to Thompson, Starrett Co., 49 Wall St., New York City. About $1,500,000.

N. Y., New York—The Amer. Academy of Arts and Letters Inc., c/o McKim, Mead & White, Archts., 101 Park Ave., has awarded the contract for a 3 story, 83 x 100 ft. educational building at 629 West 155th St. to Hegeman & Harris Co., 185 Madison Ave. About $300,000. Noted July 26.

N. Y., New York—P. J. Kearns, 2306 Creston Ave., will build a 5 story, 90 x 140 ft. apartment on Walton Ave. and Hawkstone St. About $250,000. C. Schaeffer, 304 East 150th St., Archt. Owner will build by day labor.

N. Y., New York—A. Klein, c/o Gronenberg & Lenchtag, Archts., 303 5th Ave., will build a 5 story apartment at 610 West 164th St. About $250,000. Work will be done by day labor.

N. Y., New York—The Mt. Hope Holding Co., c/o C. Kreymborg, Archt., 2534 Marion Ave., will build a 5 story apartment on 177th St. and Walton Ave. About $250,000. Work will be done by day labor.

N. Y., New York—The Unitarian Church. 500 2nd Ave., Pelham, has awarded the contract for a 3 story church and home at 244 Cathedral Pkway. to Burke Bros. Constr. Co., 1480 Bway. About $500,000.

N. Y., New York—Weewin Cart Co., c/o E. Roth, Archt., 119 West 40th St., will build a 5 story, 116 x 157 ft. apartment on University Ave. and 179th St. About $250,000. Work will be done by day labor.

N. Y., New York—The West 89th St. Realty Corp., c/o G. F. Pelham, Archt., 200 West 72nd St., will build a 9 story apartment at 318 West 98th St. About $300,000. Work will be done by day labor.

N. J., Atlantic City—The Chelsea Natl. Bank, South Carolina and Atlantic Aves., has awarded the contract for a 4 story, 70 x 100 ft. bank and office building on South Carolina Ave. to F. Warren, 132 South 17th St., Phila., Pa., $300,000. A steam heating system will be installed.

Pa., Carbondale—The Hendrick Mfg. Co., has awarded the contract for a 1 story, 100 x 220 ft. boiler shop to The Austin Co., Bulletin Bldg., Phila. About $100,000.

O., Cleveland Heights (Warrensville P. O.)—The Bd. Educ., E. K. Bryan, Clk., Lee Rd., has awarded the contract for a 3 story school on Taylor Rd. to the Hearn Constr. Co., 4500 Euclid Ave., Cleveland. $303,560. Noted Aug. 2.

O., Columbus—The city has awarded the contract for a sewage pump station on Nelson Rd. to R. H. Evans & Co., 8 East Broad St., $15,868. Equipment to Draro, Doyle Co., Dumont Bank Bldg., Pittsburgh, $6,098.

Ill., Chicago—The Lake Shore Trust and Savings Bank, c/o North Town Bldg. Corp., E. N. Winston, Pres., 38 South Dearborn St., has awarded the contract for a 4 story, 99 x 117 ft. bank and office building at 140-46 East Ohio St. to J. Rodatz, 209 South La Salle St., $300,000.

Ill., Chicago—H. T. McFarlane, 532 South Canal St., has awarded the contract for a 6 story, 115 x 116 ft. factory on Green and Van Buren Sts. for the manufacture of auto bodies, to Adams Constr. Co., 217 Clarkson St., $400,000. A steam heating system will be installed.

Wis., Union Grove—The State Bd. of Control, Capitol, Madison, have awarded the contract for a 1 story power house at the Home for Feeble Minded, here, to Immel Constr. Co., 200 North Main St., Fondulac. $34,800. Noted Aug. 2.

Minn., Rochester—St. Mary's Hospital has awarded the general contract for a 6 story addition to hospital to Heffron, Fitzgerald Constr. Co. Total cost about $2,000,000. A steam heating system will be installed.

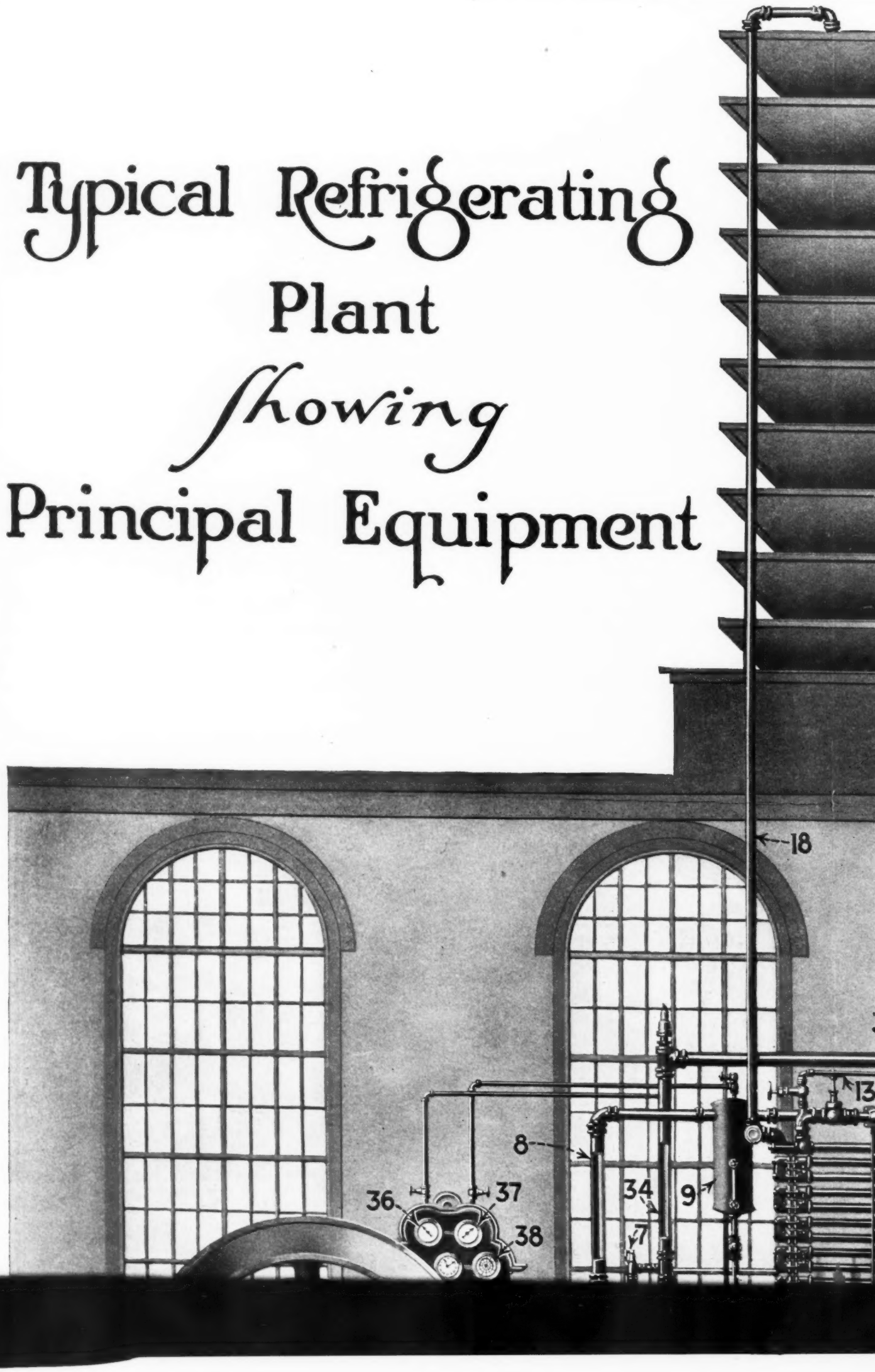
Neb., Omaha—J. K. Hyde, 1103 Westwood Ave., has awarded the contract for a 1 story, 100 x 120 ft. and 25 x 40 ft. factory and boiler house on 36th and I Sts., to J. E. Wakefield & Co., Brandeis Bldg., $60,000.

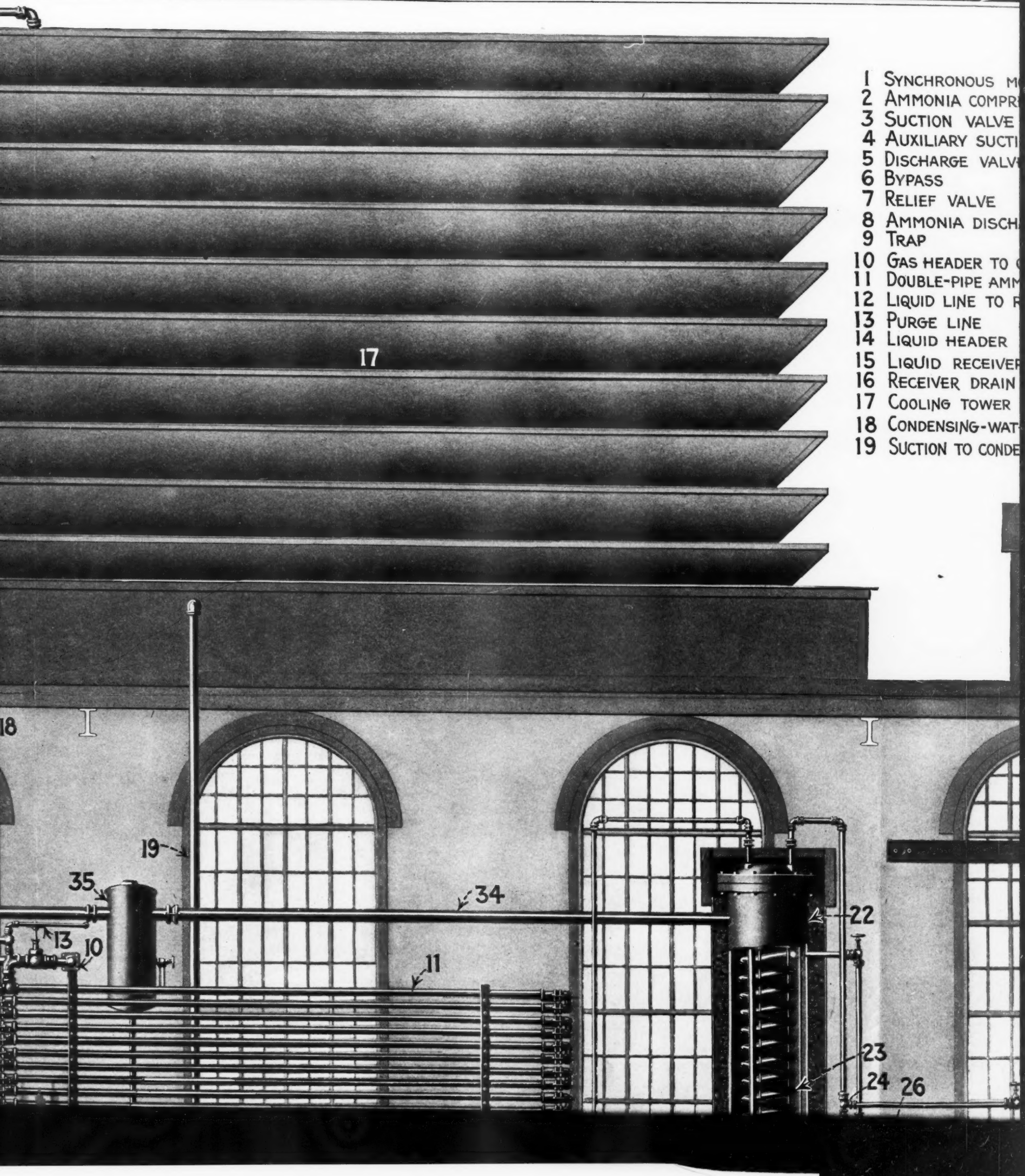
Ill., Chicago—E. Rosing, 133 West Washington St., has awarded the contract for a 12 story, 120 x 124 ft. hotel on Diversey and Pine Sts. to J. Stutt, 2655 Eastwood Ave., $1,500,000. A steam heating system will be installed.

Wis., Hartford—The Portz Bros. Malt Co., has awarded the contract for a 4 story, 64 x 120 ft. condensory and pasteurizing plant, including a power house to J. Thorn, East Main St. About $150,000.

Wis., Milwaukee—The School Bd., 10th and Prairie Sts., has awarded the contract for a 29 x 43 ft. boiler house and heating plant at the Mound St. School to P. Riesen's Sons, 1018 Humboldt Ave., $10,834. Heating to Wenzel & Henoch, 498 27th St., $13,995. Noted Aug. 16.

Typical Refrigerating Plant *Showing* Principal Equipment





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2 AMMONIA COMPR
3 SUCTION VALVE
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5 DISCHARGE VALV
6 BYPASS
7 RELIEF VALVE
8 AMMONIA DISCH
9 TRAP
10 GAS HEADER TO
11 DOUBLE-PIPE AMM
12 LIQUID LINE TO R
13 PURGE LINE
14 LIQUID HEADER
15 LIQUID RECEIVER
16 RECEIVER DRAIN
17 COOLING TOWER
18 CONDENSING-WAT
19 SUCTION TO CONDE

1 SYNCHRO
2 AMMONIA
3 SUCTION
4 AUXILIAR
5 DISCHARG
6 BYPASS
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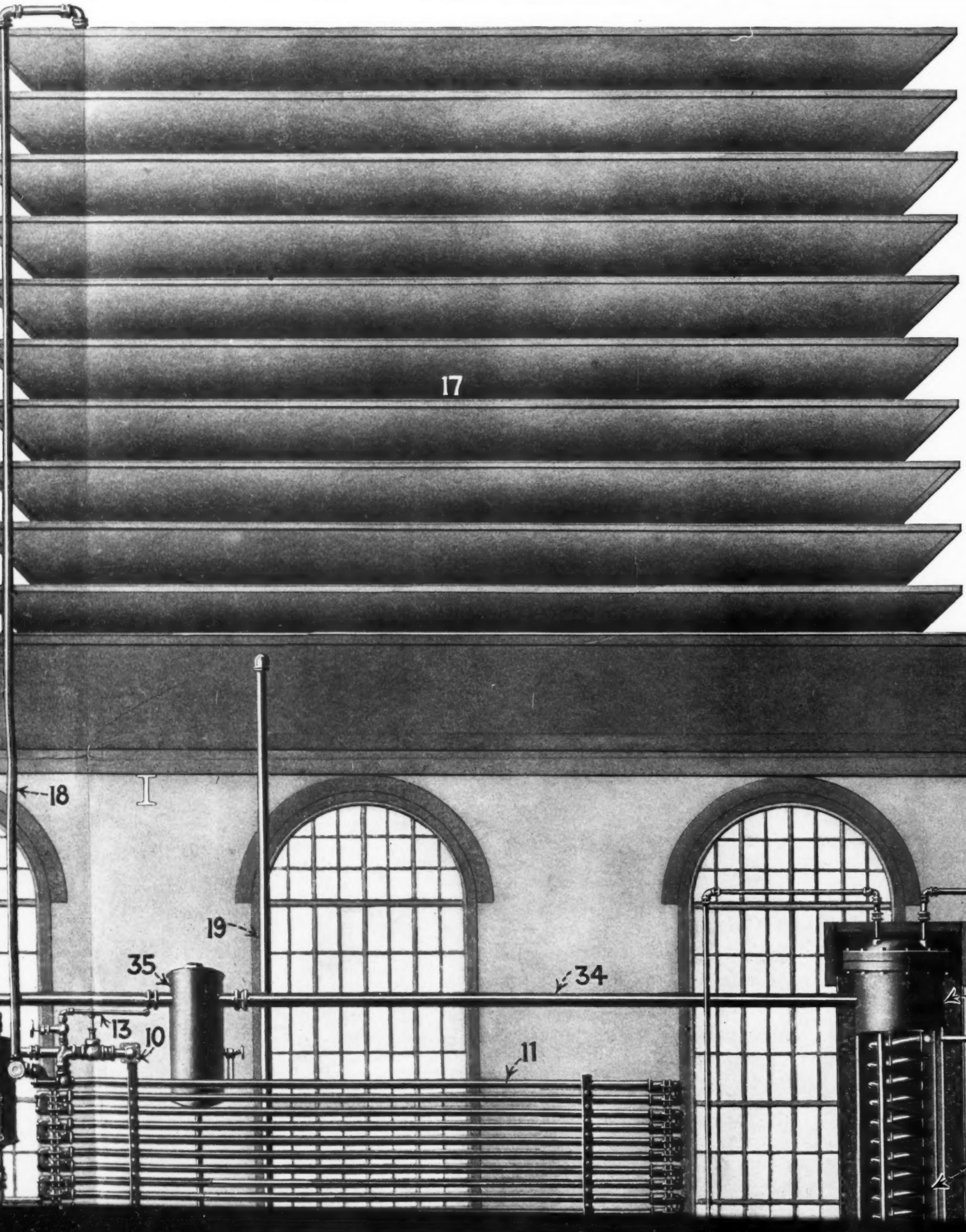
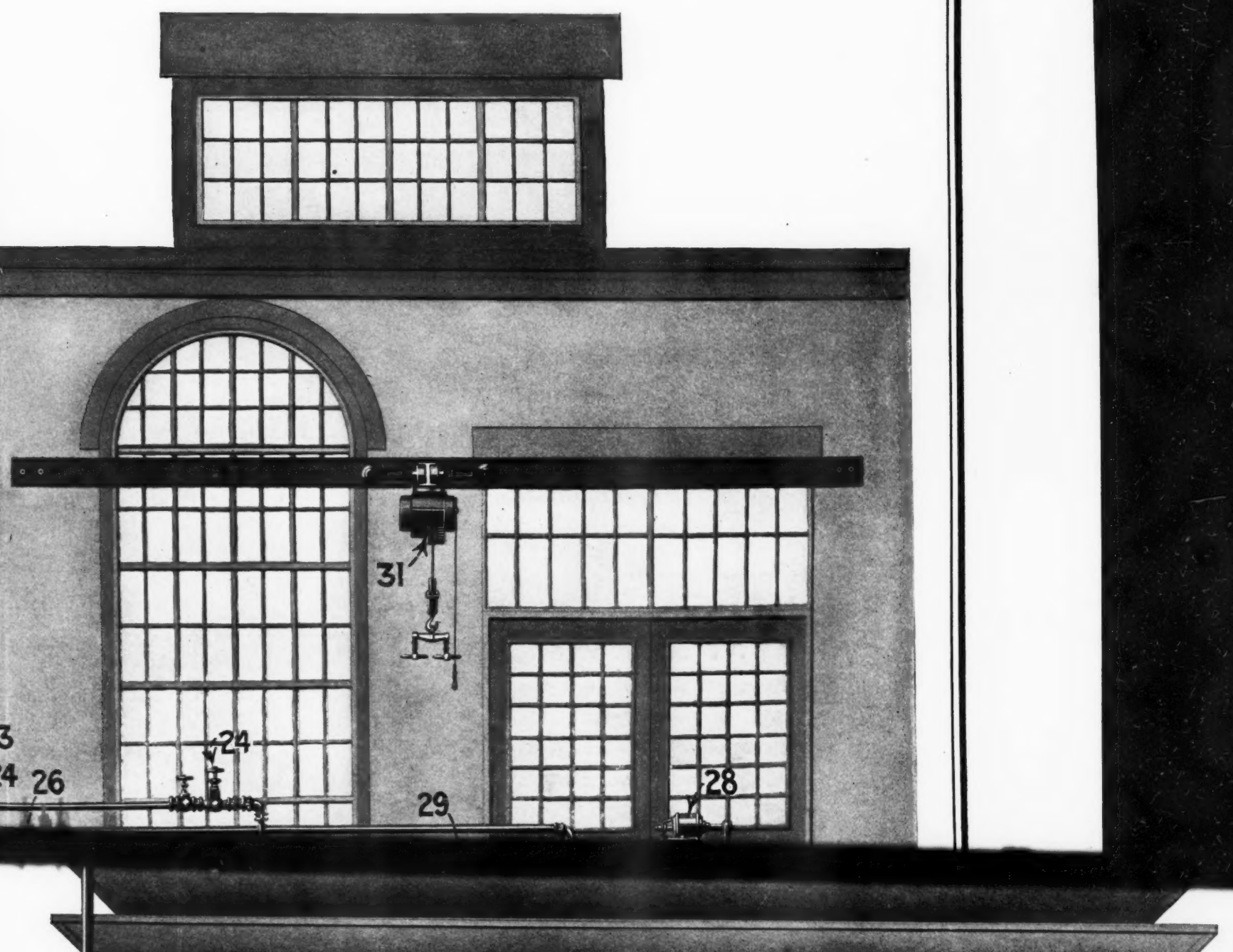


Plant

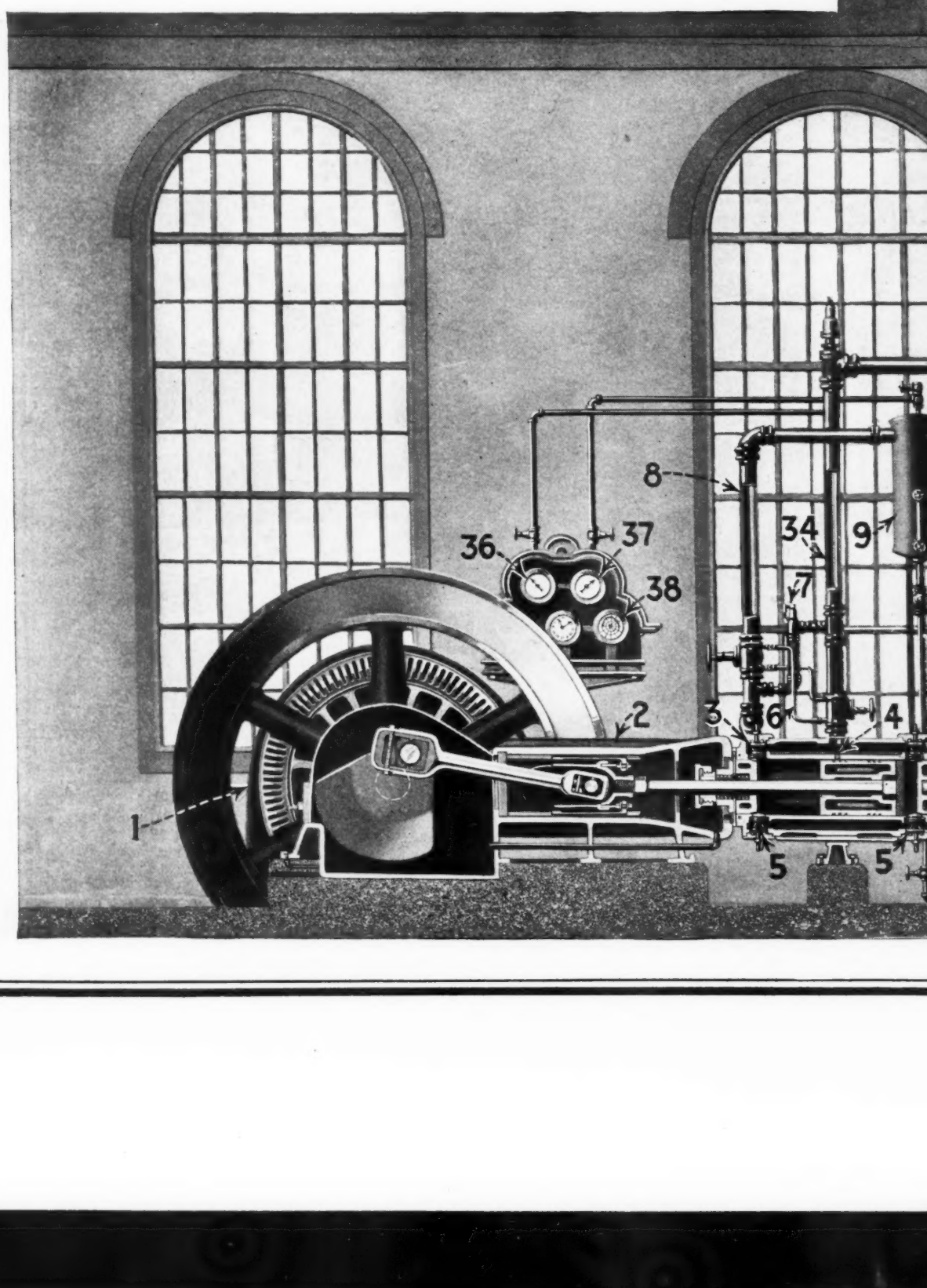
Synchronous motor
Ammonia compressor
Suction valve
Auxiliary suction valve
Discharge valves
Bypass
Relief valve
Ammonia discharge line
Trap
Gas header to condenser
Double-pipe ammonia condenser
Liquid line to receiver
Purge line
Liquid header
Liquid receiver
Receiver drain
Cooling tower
Condensing-water discharge
Suction to condensing-water pump
20 Condensing-water pump
21 Liquid line to accumulator
22 Accumulator
23 Fore-cooler ammonia coil
24 Expansion valve
25 Direct expansion coils
26 Ice tank
27 Brine agitator
28 Brine-agitator motor
29 Cold-storage brine shell-cooler
30 Brine pump
31 Ice hoist
32 Drains to purifier
33 Receiver gage
34 Suction line
35 Liquid trap
36 Suction pressure gage
37 Discharge pressure gage
38 Recording thermometer



Plant

Showing

Principal Equipment



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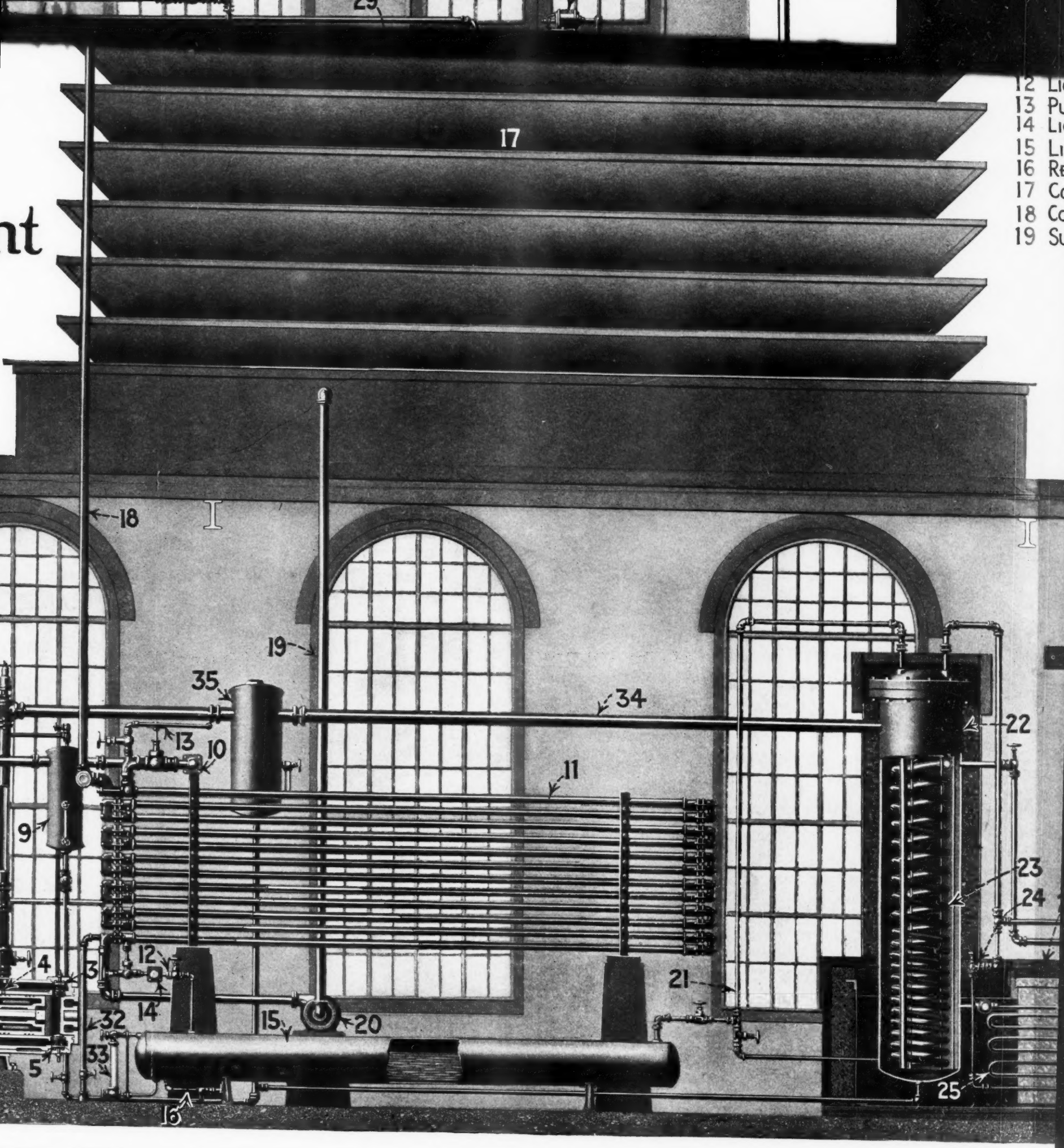

12 LIQU
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19 SUC

2 LIQUID LINE TO RECEIVER
3 PURGE LINE
31 ICE HOIST

12 LIQUI
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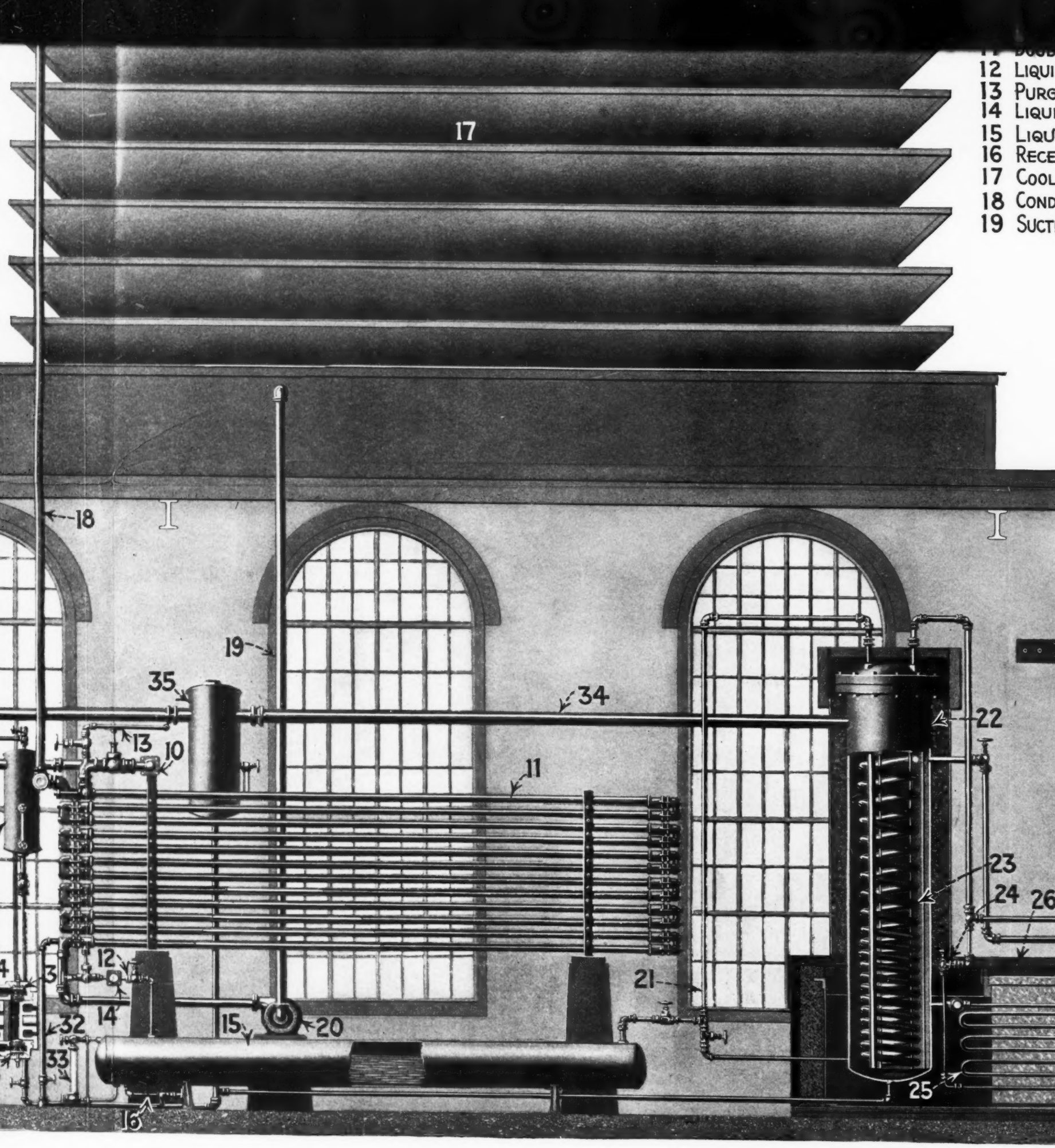
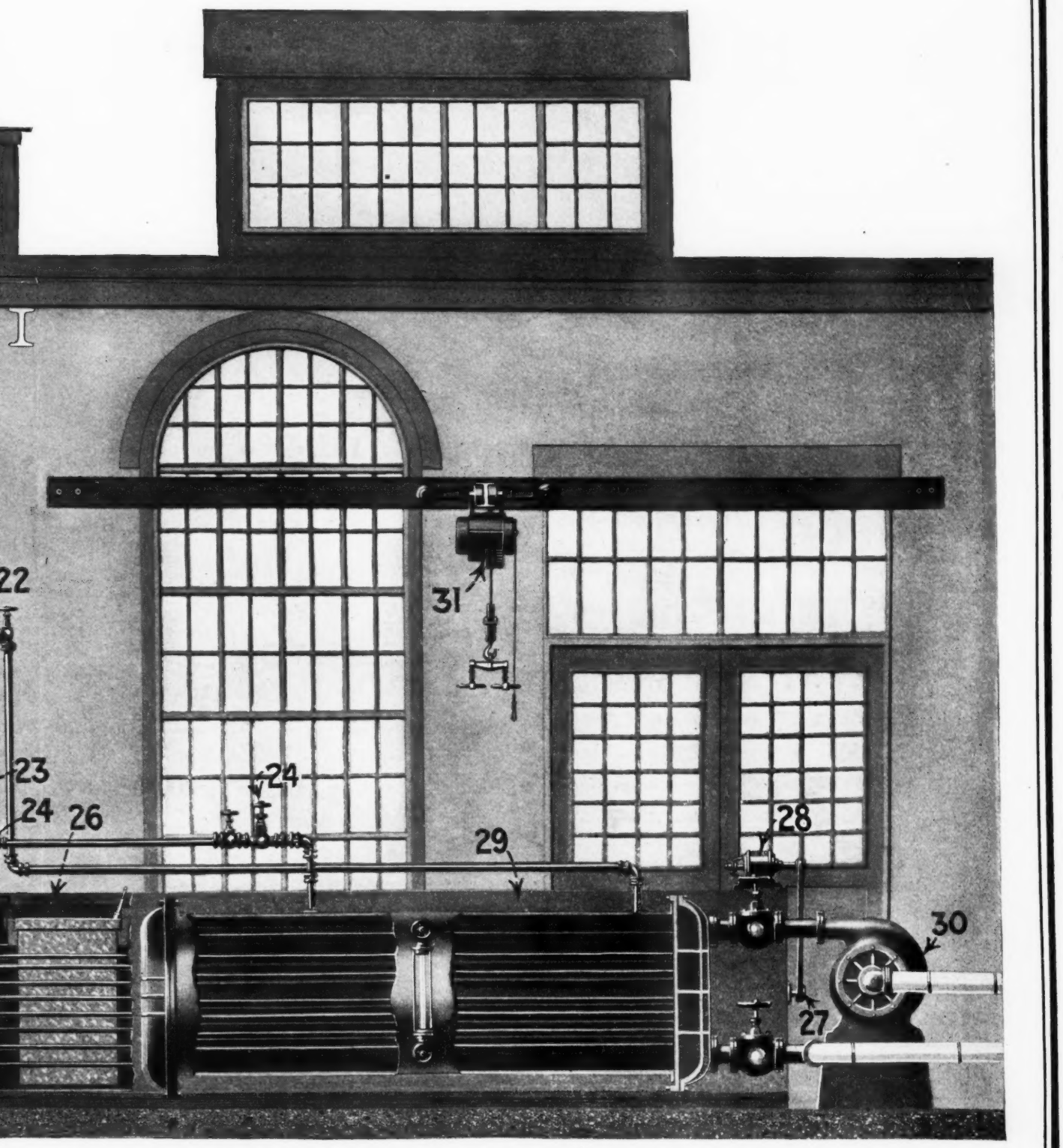
16 RECE
17 COOL
18 COND
19 SUCT



DOUBLE-PIPE AMMONIA CONDENSER

12 LIQUID LINE TO RECEIVER
13 PURGE LINE
14 LIQUID HEADER
15 LIQUID RECEIVER
16 RECEIVER DRAIN
17 COOLING TOWER
18 CONDENSING-WATER DISCHARGE
19 SUCTION TO CONDENSING-WATER PUMP

BRINE PUMP

31 ICE HOIST
32 DRAINS TO PURIFIER
33 RECEIVER GAGE
34 SUCTION LINE
35 LIQUID TRAP
36 SUCTION PRESSURE GAGE
37 DISCHARGE PRESSURE GAGE
38 RECORDING THERMOMETER